Storm Water

Treatment BMP New Technology Report

April 2004

SW-04-069.04.02

Final Report

State of California

Department of Transportation

EXECUTIVE SUMMARY

The Treatment BMP New Technology Report consolidates and standardizes information on new technologies that are part of the Department's BMP identification, evaluation and approval process described in Section 3.3.2 of the Storm Water Management Plan (SWMP). New technologies include the latest innovations in permanent storm water treatment and control, as well as existing technologies currently in use by municipal or Department of Transportation (DOT) storm water management programs, but not previously approved as BMPs by the Department.

The Department collects information for treatment BMPs not yet approved by the Department. To introduce products to the Department, manufacturers and suppliers must contact the New Product Coordinator at (916) 227-7185. Fact sheets are prepared for each identified technology and added to the report. Appendix A explains the format and content of the fact sheets found in Appendices B and C.

Fact sheets in Appendix B summarize information for technologies unapproved and untested by the Department. Appendix B has six new fact sheets included in this year's report:

- Aeration
- Detention Below Grade Storage
- Filtration Integrated Filter and Detention Basin
- Infiltration Below Grade Storage
- Litter and Debris Removal: Stormscreen™
- Water Quality Inlets

Favorable evaluations of promising BMP technologies can lead to pilot studies to gather cost and performance data. Fact sheets in Appendix C summarize information for existing and completed full-scale pilot studies of unapproved technologies. Over 130 past and current full-scale and small-scale pilot studies are listed in Table 2-1. Current studies are described in the Storm Water Monitoring and BMP Development Status Report (SW-04-069.04.01). Successfully piloted technologies may be approved and listed in the Department's SWMP to be used according to the BMP implementation procedures also contained in the SWMP. Approved BMPs listed in the Department's SWMP are not considered in this report.

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1.0 INTRODUCTION

> ***Department-Approved Treatment BMPs***
>
> **Biofiltration** (strips and swales)
> **Infiltration basins**
> **Detention basins**
> **Traction sand traps**
> **Dry weather flow diversion**

The Treatment BMP New Technology Report consolidates and standardizes information on new technologies that are part of the Department's BMP identification, evaluation and approval process described in Section 3.3.2 of the SWMP (1 Caltrans 2003). The BMP fact sheets in Appendices A and B summarize available design, construction, performance, and cost information for BMPs considered for further testing or approval.

The Department collects information for treatment BMPs not currently approved in the SWMP. To introduce products to the Department, manufacturers and suppliers must contact the New Product Coordinator at (916) 227-7185. Fact sheets are prepared for identified technologies and added to this report. The Department reviews the fact sheets to determine if a BMP warrants further research, which may include full scale pilot testing.

The Department's ongoing review of new technologies consists of evaluating the latest innovations in storm water treatment and control, including technologies used by municipal or Department of Transportation (DOT) storm water management programs. BMPs approved by the Department are excluded from this report, except for modifications to approved BMPs that require further study before approval.

1.1 REPORT ORGANIZATION

The remainder of the Treatment BMP New Technology Report is divided into two sections and three appendices.

- Section Two describes how the Department identifies and evaluates new technologies, and lists new technologies that are being evaluated in the pilot-testing program.
- Section Three provides references.
- Appendix A describes the format and information included in the fact sheets.
- Appendix B includes fact sheets that summarize unapproved technologies not yet tested by the Department. Technology fact sheets from previous years remain in Appendix B to allow annual updating as information becomes available.
- Appendix C provides fact sheets for unapproved BMPs that were or are being pilot tested by the Department.

2.0 IDENTIFYING NEW TECHNOLOGY

New BMP technology is identified by reviewing the literature on existing practices. The Department, with input from universities, consultants, regulators, third parties, and manufacturers, continually reviews BMP information reported in the literature. Manufacturers' exhibits at professional conferences also provide an opportunity to identify new technologies and products. After identification, BMPs are listed in this report.

2.1 FACT SHEETS

After identification, BMP fact sheets are developed using a standard format to facilitate comparison among BMP types. Each fact sheet is divided into a standard series of topics and presents summary information to evaluate the potential applicability of BMPs to the Department, including: design parameters, operations, maintenance, treatment effectiveness, costs, advantages and constraints. These topics are discussed in Appendix A. Completed BMP fact sheets are presented in Appendix B and Appendix C. New fact sheets added since the last annual report are noted on the first pages of Appendices B and C.

2.2 PILOTS

BMPs with potential application to the Department, as summarized in the fact sheets, may require further reconnaissance studies, small-scale, and/or full-scale pilot testing. The Department currently is conducting several pilot studies throughout the state. Fact sheets for BMPs undergoing full-scale pilot studies are presented in Appendix C. Technologies undergoing small-scale or bench scale pilot testing do not have fact sheets in Appendix C because sufficient information is not available for full-scale application by the Department. Table 2-1 presents a summary of the Department's past and current BMP pilots. Current pilots are those in any phase of pilot testing, from project scoping to final report publication. The Storm Water Monitoring and BMP Development Status Report (SW-RT-04-069.04.01) describes current pilot studies in more detail.

TABLE 2-1. CURRENT STORM WATER BMP PILOTS

Study	Dist	RWQCB	Location	Status as of January 2003	Final Report Reference No.	Professional Paper Ref. No.
Infiltration Basins (2)	7	Los Angeles	I-605/SR-91	An infiltration basin was sited and constructed in this region. Three years of monitoring are complete.	Anticipated in Spring 2004.	2,3,4,5,6
	11	San Diego	I-5/La Costa Ave.	Infiltration basin was decommissioned after summer 2001. Site not conducive for infiltration.		
Continuous Deflection Separators (4)	7	Pacoima	I-210/East Orcas Ave.	Performance monitoring complete. Final report presenting results is under preparation. Vector monitoring continues.	Anticipated in Spring 2004.	2,4,5,6
			I-210/East of Filmore St.			
	11	San Diego	SR-56	Two years water quality monitoring complete. Monitoring to continue in following three wet seasons.	Anticipated in 2009.	
			SR-56			
Detention Basins-Conventional (5)	7	Los Angeles	I-5/I-605	Three years of monitoring complete.	Anticipated in Spring 2004.	2,4,5,6,7
			I-605/SR91			
	11	San Diego	I-5/SR-56			
			SR-78/I-5			
			I-5/Manchester Ave.			
Detention Basins - bypass (4)	12	San Diego, Santa Ana	SR-73	Monitoring started in 03/04.	Anticipated in 2008.	
Detention Basins - overflow (4)	12	Santa Ana	SR-73	Monitoring started in 03/04.		
Detention Basins - semi-batch (4)	12	San Diego	SR-73	Construction to be complete by Spring 2004.		
Detention Basins – floating skimmer (4)	12	San Diego	SR-73	Monitoring started in 03/04 for 3 of 4 basins.		
Detention Basins - inlet (2)	12	San Diego	SR-73	Monitoring started in 03/04.		
Sand Traps (2)	3	Lahontan	Hwy 50 Echo Summit	Two years monitoring complete.	8	
			Hwy 50 at Lake Tahoe Airport			

Study	Dist	RWQCB	Location	Status as of January 2003	Final Report Reference No.	Professional Paper Ref. No.
Sand Traps with Filter Fabric (4)	3	Lahontan	SR-267 within Tahoe Basin	Construction scheduled for summer 2004.	Anticipated 2008.	
Austin Filter with Alt Media (2)	3	Lahontan	Hwy 50 near Tahoe	Construction complete.	Anticipated 2008.	
Bioretention (3)	4	San Fran	I-80 Toll Plaza at Oakland	Under design.	Anticipated 2008.	
	12	Santa Ana	SR-73	Under design.		
	4	San Francisco Bay	Between I-80 and I-580	Geotechnical work completed at site, aerial survey commencing of drainage area, design to begin after aerial survey.	Anticipated in 2006.	
Tahoe Small Scale Study						
Alternative media filters	3	Lahontan	Meyers Maintenance Station	The systems are in fourth year monitoring season (03/04).	Anticipated 2005.	
Sand filters	3	Lahontan	Meyers Maintenance Station	Three years monitoring complete.	9	
Chemical addition	3	Lahontan	Meyers Maintenance Station	The systems are in fourth year monitoring season (03/04).	Anticipated 2005.	
Austin Sand Filters (8)	7	Los Angeles	Paxton Park and Ride	Construction complete, no water quality monitoring,	n/a	2,4,5,6,10
			Eastern Regional Maintenance Station	Three years of monitoring complete.	Anticipated Spring 2004.	
			Foothill Maint Station			
			Termination Park/Ride			
	11	San Diego	La Costa Park & Ride			
			SR-78/I-5 Park & Ride			
	2	Central Valley	I-5 near Mountain Gate	Two seasons of monitoring complete. Monitoring to continue through the 03/04 wet season.	Anticipated 2006.	11
			Mt. Shasta Maintenance Station	One season of monitoring complete. Monitoring to begin in the 03/04 wet season.		
Delaware Filters (1)	11	San Diego	Escondido Maintenance Station	Three years of monitoring complete.	Anticipated Spring 2004.	2,4,5,6,10

Study	Dist	RWQCB	Location	Status as of January 2003	Final Report Reference No.	Professional Paper Ref. No.
StormFilter™ (1)	11	San Diego	Kearny Mesa Maintenance Station	Three years of monitoring complete. Vector monitoring is ongoing.	Anticipated 2006.	2,4,5,6
Compost StormFilter™ (CSF) (3)	12	San Diego	SR-73 -- various locations	The systems completed their second monitoring season (02/03). Vector monitoring is ongoing.	12	
Multi-Chamber Treatment Train (3)	7	Los Angeles	Metro Maintenance Station	Construction complete. No water quality monitoring.	n/a	
			Via Verde Park and Ride	Three years of monitoring complete. Vector monitoring is ongoing.	Anticipated Spring 2004.	2,4,5,6
			Lakewood Park and Ride	Three years of monitoring complete. Vector monitoring is ongoing.		
Oil/Water Separator (1)	7	Los Angeles	Alameda Maintenance Station	Three years of monitoring complete.	Anticipated Spring 2004.	2,4,5,6,13
Bio Strip (1)	7	Los Angeles	Altadena Maintenance Station (a)	Three years of monitoring complete.	Anticipated Spring 2004.	2,4,5,6
Infiltration Trench (1)			Altadena Maintenance Station (b)	Three years of monitoring complete.	Anticipated Spring 2004.	2,3,4,5,6
Bio Strip (1)			I-605/SR-91 Interchange	Three years of monitoring complete.	Anticipated Spring 2004.	2,4,5,6
Bio Strip (1)	11	San Diego	Carlsbad Maintenance Station	Three years of monitoring complete.	Anticipated Spring 2004.	2,4,5,6
Infiltration Trench (1)			Carlsbad Maintenance Station	Three years of monitoring complete.	Anticipated Spring 2004.	2,3,4,5,6
Roadside Vegetated Treatment Sites (RVTS) – Strips (8)	2	Central Valley	SR-299 EB PM 26.0	Two years of monitoring complete.	14	15,16
			I-5 SB PM 1.5			
	3		I-5 NB PM 13.5			
	4	San Francisco	US-101 NB PM 15.0			
	8	Santa Ana	SR-60 EB PM 14.0			

Study	Dist	RWQCB	Location	Status as of January 2003	Final Report Reference No.	Professional Paper Ref. No.
	11	San Diego	I-5 NB PM 70.4			
	12	Santa Ana	SR-91 EB PM 15.0			
			I-405 NB PM 2.5			
Drain Inlet Insert (6)	7	Los Angeles	Foothill Maint Station (a)	StreamGuard® installed. Three years of monitoring complete.	Anticipated Spring 2004.	2,4,5,6,13
			Foothill Maint Station (b)	FossilFilter® installed. Three years of monitoring complete.		
			Las Flores Maint Station (a)	StreamGuard® installed. Three years of monitoring complete.		
			Las Flores Maint Station (b)	FossilFilter® installed. Three years of monitoring complete.		
			Rosemead Maint Station (a)	StreamGuard® installed. Three years of monitoring complete.		
			Rosemead Maint Station (b)	FossilFilter® installed. Three years of monitoring complete.		
Bio-Swales (6)	7	Los Angeles	Cerritos Maint Station	Three years of monitoring complete.	Anticipated Spring 2004.	2,4,5,6
			I-5/I-605	Three years of monitoring complete.		
			I-605/Carson & Del Amo	Three years of monitoring complete.		
			I-605/SR-91 Interchange	Three years of monitoring complete.		
	11	San Diego	Melrose Dr./SR-78	Three years of monitoring complete.		
			I-5/Palomar Airport	Three years of monitoring complete.		
Wet Basin (1)	11	San Diego	I-5/La Costa	Three years of monitoring complete. Final report presenting results is under preparation.	Anticipated Spring 2004.	2,4,5,6,17,18,
Constructed Wetlands (1)	12	Santa Ana or San Diego	One Locations along SR-73	One wet basin to be monitored “as-is”	Anticipated in 2006.	
Storm Filter (Perlite/Zeolite) (1)	11	San Diego	Kearney Mesa Maintenance Station	Three years of monitoring complete. Vector monitoring is ongoing.	Anticipated Spring 2004.	2,4,5,6
Linear Radial Device, configuration 2 (2)	7	Los Angeles	I-5/Garber	Study is complete.	19	
			I-210/Glenada			

Study	Dist	RWQCB	Location	Status as of January 2003	Final Report Reference No.	Professional Paper Ref. No.
configuration 1 (1)			I-10/Rosemead	Study is complete.	19	
GSRD: Inclined Screen, configuration 1 (1)	7	Los Angeles	SR-170/Burbank	Study is complete.	19	
Gross Solids Removal Device (GSRD): Inclined Screen Device configuration 2 (2)	7	Los Angeles	US-101/Gaviota	Study is complete.	19	
			I-210/Orcas			
GSRD: Inclined Screen Device, configuration 3 (2)	7	Los Angeles	I-10/Halm	Study is complete.	20	
	12	Santa Ana	SR-73	GSRD on basin 1180R: Construction complete.	Anticipated in 2006.	
GSRD: Inclined Screen, configuration 4 (1)	7	Los Angeles	I-210/Christy	One year monitoring complete.	Anticipated in 2006.	
GSRD: Baffle Box (2)	7	Los Angeles	I-210/Christy (being replaced)	Study is complete. Installation replaced with Inclined screen configuration #4.	19	
			I-405/Leadwell (being replaced)	Study is complete. Installation replaced with V-screen configuration #1.		
GSRD: V-Screen, configuration 1 (2)	7	Los Angeles	I-405/Leadwell	Under construction.	Anticipated in 2006.	
	12	Santa Ana	SR-73	GSRD on basin 1085L: Construction complete. Operation began Spring 2003		

Study	Dist	RWQCB	Location	Status as of January 2003	Final Report Reference No.	Professional Paper Ref. No.
GSRD: V-Screen, configuration 2 (2)	7	Los Angeles	SR-91/Ardmore	One year monitoring complete.	Anticipated in 2006.	
	12	Santa Ana	SR-73	GSRD on basin 630L: PS&E package is under Headquarters Office of Engineers review. Estimated date of completion of construction spring 2005.	Anticipated in 2006.	
GSRD: Litter Inlet Deflector (3)	7	Los Angeles	SR-60/Garfield	Study is complete.	21	
			SR-60/Garfield			
			SR-60/Wilcox			

3.0 REFERENCES

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2. Currier, Brian, et al, January 7-11, 2001. "California Department of Transportation BMP Retrofit Pilot Program," presented at Transportation Research Board 8th Annual Meeting, Washington, D.C.

3. Currier, Brian, et al, May 20-24, 2001. "Siting, Design, and Operation of Infiltration BMPs: A Case Study," presented at American Society of Civil Engineers (ASCE) World Water & Environmental Resources Congress 2001, Orlando, FL

4. Currier, Brian and Moeller, Glen, February 25-March 1, 2002. "Lessons Learned: The Caltrans Storm Water Best Management Practice Retrofit Pilot Study," presented at International Erosion Control Association, Conference 33, Orlando, FL

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6. Taylor, Scott, August 12-15, 2002. "Selection of Best Management Practices for Retrofit in a Highway Environment," presented at StormCon 2002, San Marco Island, FL

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17. Taylor, Scott and Currier, Brian, 1999. "A Wet Pond as a Storm Water Runoff BMP—Case Study," Department of Environmental Resources Engineering, Humbolt State University, Arcata, CA

18. Taylor, Scott, et al, August 28, 2001. "Stormwater Treatment with a Wet Pond: A Case Study," presented at American Society of Civil Engineers (ASCE) Wetland Engineering and River Restoration Conference, Reno, NV

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20. Caltrans, 2003. Phase II Gross Solids Removal Devices Pilot Study: 2001-2203 Final Report, November 2003. CTSW-03-97.31.22

21. Caltrans, 2001. Caltrans Litter Inlet Deflector Study. August 2001. CTSW-RT-01-027

22. Caltrans, 2000. Guidance Manual: Stormwater Monitoring Protocols. July 2000. CTSW.RT-00-005

APPENDIX A: BMP FACT SHEET DESCRIPTION AND FORMAT

Appendix A describes the standard format used for fact sheets to facilitate comparison among the BMP types. Each fact sheet is divided into a standard series of discussion topics, which are discussed below.

A.1 BMP DESCRIPTION

A description of the BMP is presented at the top of each fact sheet. The description provides a summary of the configuration of the BMP and a general overview of the treatment process, how the BMP operates, and considerations that need to be addressed to promote maximum treatment effectiveness and functionality.

A.2 CONSTITUENT REMOVAL

The relative degree each BMP is able to remove selected groups of constituents from storm water runoff is provided in the fact sheets. The groups of constituents examined were selected based on the likelihood of occurrence in the Department's runoff at levels that would require treatment consideration. The constituent groups, removal efficiency, and confidence levels used in each fact sheet are discussed below.

A.2.1 Constituent Groups

Estimates of the technology's performance removal abilities are made for each of the following constituent groups:

- Sediment (Total Suspended Solids [TSS])
- Nutrients
- Pesticides
- Total Metals
- Dissolved Metal
- Microbiological
- Litter
- Biochemical Oxygen Demand (BOD)
- Total Dissolved Solids (TDS)

A.2.2 Constituent Group Removal Efficiency

The fact sheets report relative removal efficiencies for each of the nine general categories of constituents. Constituent removal percentages were derived from a review of the literature.

Removal efficiencies were assessed in terms of being high, medium or low. Constituent removal was quantified by first calculating the average removal percentage for all constituents within a given category. The overall assessment was then defined using the following criteria:

- *High*: average removal percentage was equal to or greater than 75 percent
- *Medium*: average removal percentage was between 40 and 75 percent
- *Low*: average removal percentage was less than or equal to 40 percent

The fact sheets provide notes with additional information regarding how the removal assessment was assigned to a given BMP.

A.2.3 Level of Confidence

The level of confidence in the constituent removal data found in the literature depended on the type and quality of the data. Assessing constituent removal from storm water BMPs is not precise; water quality monitoring studies have demonstrated the wide variability in water quality concentrations in storm water runoff. To ensure that data are of the highest quality, storm event monitoring protocols require that samples be collected according to standard procedures, such as the *Guidance Manual: Stormwater Monitoring Protocols* (22 Caltrans 2000) or equivalent procedures. The level of confidence was assessed in terms of being high, medium or low. The criteria applied for defining the confidence level were:

- *High*: The information came from either the Department's research study or a study that met the Department's quality assurance and quality control monitoring protocols.
- *Medium*: Constituent removal rates were established from the results of a scientific monitoring study or studies conducted independently of equipment manufacturers, and:
    - the BMP technology has a documented history of application for treating storm water; or
    - the treatment process was a "known" technology for treating other types of wastewater discharges; or
    - the BMP technology provided "no discharge" to surface waters under design conditions; constituent removal was assumed to be 100 percent removal although it was recognized that certain large storm events would not receive treatment.
- *Low*: The BMP monitoring program used to quantify the removal percentages and the monitoring protocols applied could not be substantiated.

A.3 DEPARTMENT SWMP CATEGORY

Each fact sheet has a section for listing one of the three general categories of BMPs identified in the Statewide SWMP that best describes the BMP being considered. These categories are as follows.

- Category I BMPs: Technology-based pollution prevention BMPs to meet the maximum extent practicable (MEP) requirements for designing and maintaining roadways and related facilities.

- Group A: The BMPs applicable to all maintenance operations.

- Group B: The BMPs used in the design of new facilities or major renovations of existing facilities.

- Category II BMPs: Controls to meet Best Conventional pollutant control Technology/Best Available Technology economically achivable (BCT/BAT) requirements for construction projects.

- Category III BMPs: Treatment BMPs to meet MEP requirements.

Currently this report only focuses on Category III BMPs.

A.4 KEY DESIGN ELEMENTS

This section identifies important design considerations that have been highlighted by vendors or discovered through testing. Ancillary facilities assumed to be used in conjunction with the new technology are also listed in this section. An example would be including a detention basin downstream of a chemical treatment technology to capture flocculated particles.

A.5 SCHEMATIC

If appropriate, a schematic figure is provided to depict a typical design plan or cross-section with the major components identified.

A.6 CAPITAL, OPERATIONAL, AND MAINTENANCE COSTS

Assessments pertaining to the costs of building, operating and maintaining each BMP are also provided on each fact sheet. To provide the Department with as much information as possible for their evaluations, two pieces of information are provided on BMP costs:

- Level of confidence in the available data
- General assessment of the BMP's overall costs

A.6.1 Level of Confidence

The level of confidence in the costs to build and operate a BMP depends on the type and quantity of information found in the literature. Use of cost information developed for municipal storm water programs was not considered to be directly relevant to the Department's facilities. The right-of-way costs and construction costs of major highway transportation projects are typically much greater than the typical suburban street or arterial road that might be constructed by a municipal public works Department. Furthermore, operations and maintenance costs of facilities along major freeways is typically much more expensive than similar municipal facilities because of limited access and the need for traffic control. The level of confidence was assessed in terms of being high, medium or low. The criteria applied for defining the confidence level of the cost estimates were:

- *High:* Unit cost information was available from a facility designed and constructed by the Department or a similar state transportation department.
- *Medium*: Cost information was available from several similar facilities constructed under municipal storm water programs.
- *Low*: No cost information was available from a similar BMP facility that could be independently verified. Construction costs were extrapolated from available pricing information.

A.6.2 Cost Estimate Assessment

The cost effectiveness for each BMP was assessed in terms of its equivalent uniform annual cost (EUAC) relative to a detention basin. A four-quadrant system was used as a tool to rate each BMP (ie). One of the four quadrants was colored based on the rating key.

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Figure A-1. Rating key for cost effectiveness.

The cost estimates were defined by first calculating the typical range of costs for constructing or operating BMPs on a per acre basis. The acres represented the drainage area served by the BMPs. Operation and maintenance costs were then added based on the BMPs design life. The EUAC for a particular BMP was estimated and then compared to that of a detention basin. If the EUAC was higher than a detention basin, then it was marked as a higher cost using the quadrant rating key.

The benefit of the BMP was evaluated relative to the performance of a typical detention basin. If the constituent removal was greater than that of a detention basin, then the BMP was marked as having a greater benefit.

A.7 ISSUES AND CONCERNS

This section presents issues and concerns to be considered when evaluating the appropriateness of a BMP for any of the Department’s facilities. This information is divided into two categories: maintenance and project development. Within each category is a standard set of topics. The same topics are included in every fact sheet to facilitate comparisons between BMPs.

A.7.1 Maintenance

- *Requirements:* Summarizes routine maintenance tasks required to keep the BMP functional.
- *Nuisance Controls:* Identifies whether the BMP has the potential to create odors, breed mosquitoes, or attract pests.
- *Traffic Safety:* Identifies the level of potential traffic control during BMP servicing.

- *Staffing/Equipment:* Identifies the level of staff and training required to perform the maintenance. Identifies specialty equipment.

A.7.2 Project Development

- *Right-of-Way Requirements:* Identifies relative space requirements to install the BMP.
- *Siting Constraints:* Identifies siting considerations and limitations, such as soil types, slope of the land, distance from existing infrastructure or other natural features, and regulatory requirements.
- *Design Complexity:* Identifies major components and equipment requirements, and operational controls or limits.
- *Retrofit Potential:* Identifies the potential for retrofitting existing Department facilities.

A.8 BMP SPECIFIC ADVANTAGES AND CONSTRAINTS

This section lists additional advantages and constraints of the BMP that were not covered in the previous sections. Information presented may include impacts from hydrologic characteristics and weather conditions in California, experiences from actual installations, and expansion of particular points discussed in previous sections of the fact sheet.

A.9 SOURCES

The fact sheets also include sources of information where appropriate (e.g., for proprietary technologies, vendor contact information is provided).

APPENDIX B: NEW TECHNOLOGY FACT SHEETS

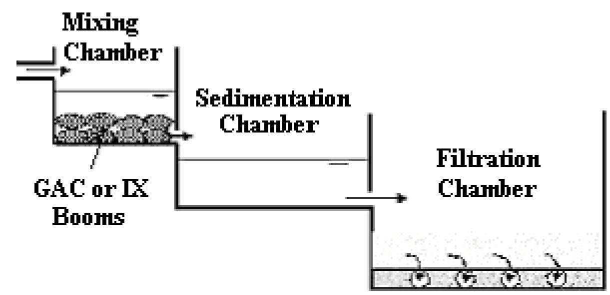
Appendix B presents fact sheets for new technologies that are not approved or rejected, and have not been pilot tested by the Department. Technology evaluations in the attached fact sheets are ongoing, and the assessment of these technologies may be revised in future reports. The evaluations that appear were derived from a review of information that was frequently limited to manufacturer's claims. Treatment BMP technologies are presented in the following order:

Technology Type	Page	Available Storm Water Products
Filtration – Earthen Construction Modified Austin Sand Filter	B-45	Non-proprietary design
Filtration – Integrated Filter and Detention Basin (NEW FACT SHEET)	B-47	Aqua-Filter™
Filtration – Pressure Filters	B-49	n/a
Filtration – Self Backwashing Filters	B-51	n/a
Infiltration - Trenches with Alternative Backfill	B-53	Rainstore[3]
Infiltration - Below Grade Storage (NEW FACT SHEET)	B-55	Cultec Contactor, Cultec HVLV™, StormChamber™
Litter and Debris Removal – "Y" Mesh Litter Bags	deleted	"Y" mesh litter bag fact sheet deleted because the concept is similar to GSRD's fact sheets in Appendix C.
Litter and Debris Removal – Breakaway Bags	B-57	Net Tech G.P.I .
Litter and Debris Removal – Hydrodynamic Separators	B-59	Aqua-Swirl, Stormceptor, Storm Separator, StormVault, Stormgate Separator, Vortechs™
Litter and Debris Removal – StormScreen™ (NEW FACT SHEET)	B-61	StormScreen™
Sedimentation – Grit/Water Separators	B-63	n/a
Sedimentation – Plate and Tube Settlers (note: similar to MCTT in Appendix C-34)	B-65	n/a
Sedimentation – StormTreat Wetland Systems	B-67	StormTreat™
Water Quality Inlets (NEW FACT SHEET)	B-69	Aqua-filter™, Aquashield, BaySaver®, Downstream Defender™, EcoStorm®, SNOUT, Stormceptor™, Stormgate™, Stormgate Seperator™, Stormfilter™,Catchbasin Stormfilter™, Vortechnics™, V2B1™

BMP Fact Sheet
Adsorption/ION Exchange GAC or IX Media Added to Sedimentation Basin Influent

Description:

Influent storm water could be mixed with granular activated carbon (GAC), ion exchange (IX) resin or both at the inlet of an extended detention basin (EDB) or a sedimentation chamber preceding a sand filter. A mixing tank with centrifugal mixing pumps can be installed at the inlet flow distribution system of a sedimentation basin. As the storm water enters the mixing chamber tank, it comes in contact with GAC and IX. After mixing, the storm water flows to the sedimentation basin. The GAC and IX is in suspension with the storm water until it settles with other solids in the sedimentation tank. As an alternative, the extended detention pond influent storm water could flow over a bag or sack filled with GAC or IX resin, or both. These sacks could be placed in detention pond inlets or other structures.



Key Design Elements:

1. Media type and dosing rate.
2. Media feed and storage systems.

Ancillary Facilities

Sedimentation and/or filtration facilities downstream.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	●	○
Total Metals	●	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in literature.
- Removal efficiency approximated for a combination of IX and GAC
- Suspended solids and other constituents attached to the solids settle out in the pond. Heavy metals that are not dissolved but attached to particles might be removed with the settled solids.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Maintenance same as Austin Sand Filter except for replacement of spent GAC/IX powder. The replacement frequency of the GAC/IX powder would depend on storm water flow and constituent concentrations. The replacement will be easier for the option using a bag than for the option using powder. If centrifugal mixing pumps are used, they will also have to be maintained.
- *Nuisance Control:* None identified.
- *Traffic Control*: Unlikely.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris, as well as to reduce GAC/IX.

Project Development:

- *Right-of-Way Requirements*: Moderate
- *Siting Constraints*: Power required if the centrifugal pumps are used.
- *Retrofit Potential*: Space required for influent chamber to mix GAC/IX.
- *Construction*: Requires existing filter.

Advantages:

- This BMP will remove additional constituents that aren't removed in an EDB or filter.

Constraints:

- The GAC/IX powder will accumulate in the sedimentation chamber unless the design is such that the influent flows over a GAC/IX bag.

Sources:

- Mercado, Shery or Jimmy Lam. GAC Stormwater Application. Calgon Carbon Corporation.
- http://www.calgoncarbon.com, April 2000.

Literature Sources of Performance Demonstrations:

- None identified.

Description:

To help remove organics from storm water, GAC has been proposed to be added to the treatment train of existing or proposed sand filters. A GAC layer could supplement the current sand media filter and would act as both a filtering media and adsorption layer. This option would require a detention pond upstream of the filter to provide sufficient pretreatment. One approach to consider is the GAC Sandwich Filter from Calgon Carbon Corporation (patent-pending), which removes a broad spectrum of pesticides and herbicides. This vendor claims to improve the effectiveness of slow sand filters by using a layer of GAC between two layers of sand. The system retains the advantages of traditional slow sand filtration while incorporating GAC's ability to remove organic compounds. Existing slow sand filters can be used for retrofit applications, which eliminates the need for a major capital investment and substantially reduces the time required to install GAC facilities.

Constituent Removal:

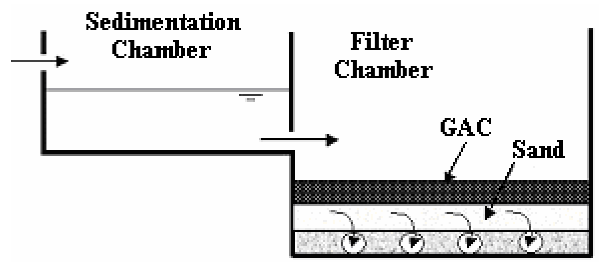
Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	●	○
Total Metals	◒	○
Dissolved Metals	◒	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- Nitrate and nitrite levels may actually increase due to nitrification.
- Performance data from Lake Angel Detention Pond in Orange County (University of Central Florida and State DOT, June 1991).

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Adsorption media type and depth.

<u>Ancillary Facilities</u>

Upstream sedimentation facilities required.
Normally the GAC layer would be used in conjunction with a sand filter.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	◳	○

● High	◒ Medium	○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Routine maintenance may include periodic sediment and debris removal as well as spent GAC disposal/regeneration. Layered media may complicate maintenance.
- *Nuisance Control:* Standing water will occur if media filter is clogged.
- *Traffic Control*: Unlikely.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment, debris and periodically replace carbon.

Project Development:

- *Right-of-Way Requirements*: Same as Austin filter.
- *Siting Constraints*: Same as Austin filter.
- *Retrofit Potential*: Designed to be used with existing sand filters.
- *Construction:* Same as Austin filter.

Advantages:

- The GAC layer will act as both an adsorption layer and a filtering media. This option will provide removal of some organic constituents.

Constraints:

- Frequent clogging and short bedlife.
- Bacterial growth.
- Spent GAC may be a hazardous waste.

Sources:

- Mercado, Shery or Jimmy Lam. GAC Stormwater Application. Calgon Carbon Corporation. http://wwwcalgoncarbon.com, April 2000.

Literature Sources of Performance Demonstrations:

- GAC has already been used as a media filter to treat storm water during a study in Florida (University of Central Florida and State Department of Transportation, June 1991). This study describes the use of GAC filer beds in series to reduce the potential concentration of total trihalomethane at the Lake Angel Detention Pond in Orange County. The pond accepted runoff from an interstate highway and a commercial area.

Description:

Granulated Activated Carbon (GAC) adsorption is typically used to remove volatile organic compounds (VOCs) in water for potable uses. In addition to a removal efficiency greater than 99% for VOCs, it is also effective for treatment of synthetic organic chemicals. With GAC treatment, contaminated water passes through a column of GAC where organic compounds are removed by adsorption onto the carbon granule surface. Once the carbon can no longer adsorb pollutants from the water, it must be regenerated or replaced with fresh new carbon. Two types of designs are commonly employed for GAC: the pressurized contactor unit and the gravity-flow unit (which is similar to the gravity media filter). For storm water application, a GAC canister could be placed at the outlet of an extended detention basin (EDB), and the basin effluent would either be pumped through the canister or allowed to flow through it by gravity. The GAC system can be designed to operate either by gravity or pressure. Performance of the GAC canister at a sedimentation pond outlet will depend highly on the performance of the pretreatment. The sedimentation pond will also provide flow equalization to the GAC canisters.

Constituent Removal:

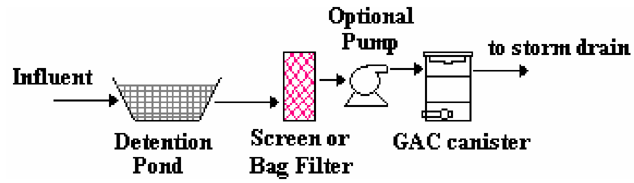
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	●	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Absorption media type and depth
2. Container and hydraulic system

<u>Ancillary Facilities</u>

As with other granular media devices, sedimentation facilities should be provided upstream.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: The mechanical equipment needs to be maintained. Spent GAC will have to be replaced or regenerated periodically. The GAC will need to be inspected.
- *Nuisance Control:* N/A.
- *Traffic Control*: N/A.
- *Staffing/Equipment:* Staff and equipment needed to replace media.

Project Development:

- *Right-of-Way Requirements*: Small footprint relative to sedimentation basin.
- *Siting Constraints*: Restricted to sites where nearby power or gravity flow is available.
- *Retrofit Potential*: May be added to existing EDBs.
- *Construction:* Requires pump or placement of GAC unit to accommodate gravity flow.

Advantages:

- Compact system at the EDB outlet.
- An effective way of removing pesticides.
- Effluent quality does not vary with pollutant concentration; only the bed life varies.
- A reliable treatment process.

Constraints:

- Spent GAC has the potential of being considered a hazardous material and will need to be disposed of properly. Hauling costs may be excessive.
- The carbon must be shipped off-site for regeneration or disposal by a licensed company. One option would be to dispose of the spent GAC and replace it with new GAC. Regeneration of the GAC onsite is considered to be technically unfeasible and cost prohibitive. Another is to replace regenerated GAC cylinders and regenerate spent cylinders at an off-site location, which is commonly done by small-scale commercial and industrial users.
- GAC may promote considerable microbial growth on the carbon surface.
- Disinfection prior to GAC adsorption is not viable since the GAC removes disinfectants.
- Potential clogging of the GAC if pretreatment does not remove enough suspended solids, oil and grease.

Sources:

- Evans, Max. Mailed Correspondence. Oil or Gas Recovery from Parking Areas. Culligan Water, May 2000.
- Macpherson, John. Phone Conversation. GAC Quilted Blanket Filter. The IT Group, (425) 486-5515 ext. 232. April 2000.
- McMillen, Brent. Faxed document. Activated Carbon Contaminants and Costs. CPL Carbon Link Corporation, April 2000.
- Nitchman, Craig. Faxed Document. Carbon Usage Rate. Calgon Carbon Corporation, April 2000.
- Wilburn, Tom. Phone Conversation. GAC Quilted Blanket Filter Production. D. R. Shannon Company, (800) 255-1032. April 2000.
- Mercado, Shery or Jimmy Lam. GAC Stormwater Application. Calgon Carbon Corporation. http://www.calgoncarbon.com, April 2000.
- Jaubert, Michael. GAC Cost Estimates. Waterlink Barnebey Sutcliffe: Pur Air Division http://www.waterlink.com, April 2000.
- Mercado, Shery and Jimmy Lam. Activated Charcoal Cloth. Calgon Carbon Corporation. http://www.calgoncarbon.com/product/charcoalcloth.htm, April 2000.

Literature Sources of Performance Demonstrations:

- Wanielista, M. P., et al. Evaluation of the Stormwater Treatment Facility at the Lake Angel Detention Pond, Orange County, Florida. Florida State Department of Transportation and University of Central Florida, Gainesville. June 1991.

Description:

Ion exchange (IX) is a sorption process whereby a medium such as a resin removes one ion from a solution and replaces it with another. Resins are comprised of fixed ionic groups that are balanced by counter-ions of opposite charge to maintain electroneutrality. These counter-ions exchange with the ions in solution. As water passes through the resin bed in a storm water treatment system, contaminant ions in the water are exchanged with ions on the resin surface, thus removing the contaminant ions from the water and concentrating them on the resin. The resin is frequently regenerated to remove the contaminant from the resin surface and replenish the resin with the original exchange ion. A sedimentation basin and possibly a media filter will be needed in front of the resin bed to remove particles and prevent clogging of the IX resin. A media filter may also be necessary after the sedimentation basin and in front of the IX resin. The IX resin could either be placed in pressure vessels or in a canister at the pond outlet.

Constituent Removal:

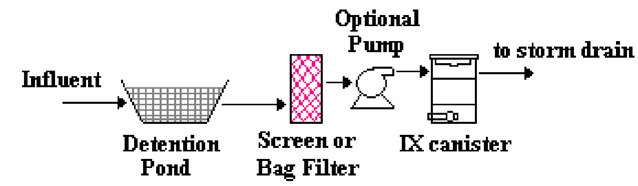
Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	○
Nutrients	◒	○
Pesticides	◒	○
Total Metals	●	○
Dissolved Metals	●	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	◒	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Ion exchange resin type, size, and bed depth.
2. Hydraulic system for moving water through resin bed.

<u>Ancillary Facilities</u>

Sedimentation and possible filtration upstream of the IX unit.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	▝	●

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Resin must be periodically inspected. Spent resin or regenerant brines must be removed and disposed of properly. Measures must be taken to make sure that the resins do not dry out during dry season. Mechanical equipment must be maintained. Because of the constraints, on-site regeneration is not considered feasible. The IX resin must be shipped off-site for regeneration or disposal by a licensed company.
- *Nuisance Control:* N/A
- *Traffic Control:* If located along a shoulder or median, maintenance activities will require traffic controls.
- *Staffing/Equipment:* Staff and equipment required to change out-spent resin.

Project Development:

- *Right-of-Way Requirements:* Small footprint.
- *Siting Constraints*: Restricted to sites where nearby power or gravity flow is available. Power is required if the system chosen is pressurized.
- *Retrofit Potential:* Potential greater for existing detention ponds.
- *Construction:* None.

Advantages:

- They provide a compact system at the EDB outlet.
- Effluent quality does not vary with pollutant concentration; only the bed life varies.
- As long as the effluent is monitored. appropriately, the adsorption capacity can be easily assessed to determine when the IX unit should be replaced.

Constraints:

- Exhausted IX has potential to be considered a hazardous material and will need to be disposed of properly.
- Hauling costs may be excessive.
- IX resins could dry out if not kept wet.
- Potential clogging of the resin if pretreatment does not remove enough suspended solids, oil and grease.
- The requirement for flow equalization.

Sources:

- Monat, J. Synergies Between Ultrafiltration & Ion Exchange. http://www.kochmembrane.com/technical_info/separation.htm. April 2000.

Literature Sources of Performance Demonstrations:

- Clifford, D.A., Department of Civil and Environmental Engineering, University of Houston, Texas, Water Quality and Treatment: A Handbook of Community Water Supplies 4th edition, 1990.
- Montgomery, James M, Consulting Engineers, Inc. Water Treatment Principles and Design, 1985.

Description:

The MICROGEN™ Stormwater Aeration System consists of a flexible suction hose or flexible pipe, a micro-bubble generator (pump, nozzle and S-tube with pressurized air return), and a flexible discharge hose or pipe. Micro-bubble generator is self-priming and able to pump solids to 2.5in diameter, so direct suction from storm water ponds or lakes is possible without filtration.
The MICROGEN™ Stormwater Aeration System quickly raises Dissolved Oxygen levels in storm water, pond or lakes, and estuaries after a rainstorm.

Key Design Elements:

1. Microgen™ produces bubbles with an average of 10 microns in diameter. This bubble is tens of thousands times smaller than the average bubble size produced by a venture ejector, fine bubble membrane or ceramic diffuser, brush aerator or fountain

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	◒	○
TDS	○	○

Notes:

- Oxygen tanks can be mounted on a trailer with a single or multiple micro-bubble generators and a diesel generator, in order to diffuse pure oxygen rather than ambient air into storm water.
- The life expectancy of the Microgen™ system is 15 years.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	◲	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Unknown
- *Nuisance Control:* Ponds that have permanent standing water need mosquito controls within exiting basins.
- *Traffic Control*: Unlikely.
- *Staffing/Equipment:* Unknown

Project Development:

- *Right-of-Way Requirements*: Ponds that have permanent standing water need mosquito controls within exiting basins.
- *Siting Constraints*: Ponds that have permanent standing water need mosquito controls within exiting basins.
- *Retrofit Potential*: Ponds that have permanent standing water need mosquito controls within exiting basins.
- *Construction:* Unknown

Advantages:

- The MICROGEN^{TM} Stormwater Aeration System can be mobile or stationary.
- The MICROGEN^{TM} system avoids the need for continuous electrical power which a brush aerator or fountain would need.
- Dissolved oxygen levels achievable with the MICROGEN^{TM} system are significantly higher than would be possible with other aeration devices.

Constraints:

- Because of high nitrogen content in ambient air, the tiny bubble size, and long detention time, there is a significant risk, when using ambient air, to supersaturating the discharge water with nitrogen. This can be harmful to fish and their eggs. Therefore, a gas depressurization chamber on the discharge is required if ambient intake air is used. However, pure oxygen tanks or a pure oxygen generator can be used without this requirement.

Sources:

- Aqua Master, www.aquamasterfountains.com
- Tom Frankel, Stamford Scientific International, INC.
- www.stamfordscientific.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Adding chemical coagulants to storm water influent is one way to remove more sediment and associated contaminants and nutrients in an Extended Detention Basin (EDB) without physically modifying the basin. Several coagulants have recently been evaluated for this application such as alum ($Al_2(SO4)_3 18H_2O$). The aluminum hydroxide precipitate, $Al(OH)_3$, forms a floc that attracts and absorbs colloidal particles, thus clarifying the treatment water. Removal of additional dissolved phosphorus occurs. Alum can be injected into major storm sewer lines on a flow-weighted basis during rain events. When added to runoff, alum forms non-toxic precipitates that combine with phosphorus, suspended solids and heavy metals, causing them to be rapidly removed from the treated water. In a typical alum storm water treatment system, the coagulant is injected into the storm water by a variable-speed chemical metering pump on a flow-weighted basis so the same dose is added regardless of the storm sewer discharge rate.

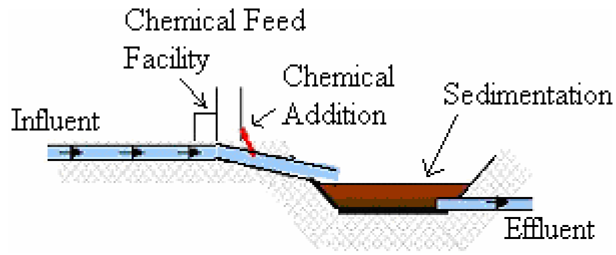
Since Al^{+3} can be toxic to aquatic life, floc formation takes approximately 45 to 60 seconds and should be complete before treated storm water is discharged to receiving water. Alum injection locations must be carefully selected to allow at least 60 seconds of travel time after alum is added to the storm water and before discharge to the watershed.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	●	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Chemical dose.
2. Chemical feed and storage facilities.
3. Mixing Facilities.

<u>Ancillary Facilities</u>

Detention basin must be provided downstream to capture flocculated particles.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Mechanical equipment must be inspected and maintained on a regular basis. Sludge must be removed periodically.
- *Nuisance Control:* Vector control is an issue for detention basins.
- *Traffic Control*: Not commonly sited on the shoulder.
- *Staffing/Equipment:* Crews must be trained to maintain chemical addition system.

Project Development:

- *Right-of-Way Requirements*: Small footprint for chemical addition system.
- *Siting Constraints*: The site for this system must include access to electricity and be large enough for a central housing unit and storage tank.
- *Retrofit Potential*: May allow smaller detention basins where right-of-way is constrained.
- *Construction:* Access to the chemical storage facility will be needed for deliveries. Need enough head for mixing.

Advantages:

- The observed accumulation rate of alum floc in sediments of receiving waters is low due to floc consolidation over time and incorporation of alum floc into existing sediment.
- Alum treatment achieves high nutrient, heavy metal and fecal coliform removals.
- Dry alum sludge has chemical characteristics suitable for general land application or in agricultural sites.
- Construction costs for alum storm water treatment feed systems are largely independent of the drainage area to be treated and depend primarily upon the number of outfalls to be retrofitted.

Constraints:

- The pH must be maintained within a range of 5.5 to 7.5 to prevent formation of Al^{+3}, which has toxic effects on aquatic life.
- Sludge removal frequency and method will have to be studied.
- Alum forms voluminous metal hydroxides that are very difficult to dewater.
- Safety issues related to the chemical storage facility need to be considered.
- Appropriate mixing must be provided at the point of chemical addition.
- Optimum alum dose may vary with each storm.

Sources: None.

Literature Sources of Performance Demonstrations:

- Harper, H. H., et al. Alum Treatment of Stormwater: The First Ten Years Environmental Research & Design. 1997.
- Harper, H. H., et al. Alum Treatment of Stormwater Runoff: An Innovative BMP for Urban Runoff Problems. Environmental Research & Design, Inc. 1996.
- Harper, H. H., et al. "An Assessment of An In-Line Alum Injection Facility Used To Treat Stormwater Runoff in Pinellas County, Florida." Sixth Biennial Stormwater Research and Watershed Management Conference. September 14, 1999.
- Harper, H. H., et al. "The Evaluation & Design of an Alum Stormwater Treatment System to Improve Water Quality in Lake Maggiore in St. Petersburg, Florida." Fifth Biennial Storm water Research Conference. Nov 5 to 7, 1997.
- Harper, H. H., et al. "Removal of Microbial Indicators from Stormwater Using Sand Filtration, Wet Detention, & Alum Treatment Best Management Practices." Sixth Biennial Stormwater Research and Watershed Management Conference. September 14, 1999.
- Harper, H. H, " Long-Term Performance Evaluation of the Alum Stormwater Treatment System at Lake Ella, Florida." Final Report Submitted to the Florida Department of Environmental Regulation, Project WM339. December 1990.
- Price, F. A. & D. R. Yonge. Enhancing Containment Removal in Stormwater Detention Basins by Coagulation. Washington State University: Department of Civil and Environmental Engineering.
- Yonge, D. & F. Price. Stormwater Contaminant Removal by Chemicals: Enhancing Contaminant Removal in Stormwater Detention Basins by Coagulation. Research Project T9234-11. Washington State Department of Transportation (WSDOT). April 1995.

Description:

Adding chemical coagulants to storm water influent is one way to remove more sediment and associated contaminants and nutrients in an Extended Detention Basin (EDB) without physically modifying the basin. Several coagulants have recently been evaluated for this application such as polyacrylamide (PAM). PAM is one of several water-soluble coagulants that have demonstrated proficiency at reducing soil erosion when added at low concentrations to irrigation water. This reduction is accomplished by improving the stability of soil aggregates and flocculating suspended solids. When added to irrigation water, PAM removes most sediments, phosphorus, and pesticides from the resultant return flow. It also reduces the return flow BOD and increases infiltration, which reduces runoff water quantity. PAM could be used in a gel log or composite block placed in a basket or nylon mesh bag.

Constituent Removal:

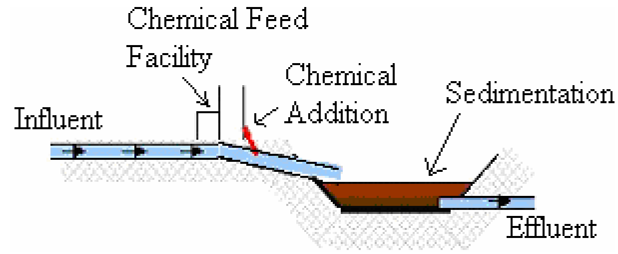
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	◒	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations.

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Chemical dose.
2. Delivery and storage system.
3. Mixing facilities.

<u>Ancillary Facilities</u>

Detention basin must be provided downstream to capture flocculated particles.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	●

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Mechanical equipment must be inspected and maintained on a regular basis. Sludge might need to be removed frequently. After each storm the sedimentation basin and the dosing systems should be inspected. The sedimentation basin would need to be cleaned when necessary. The dosing system should be recharged with PAM or PAM/$CaCO_3$ composite mixture when there is no residual gel.
- *Nuisance Control:* N/A.
- *Traffic Control*: Rarely located along a shoulder or median.
- *Staffing/Equipment:* Staff and equipment necessary to replenish PAM supply.

Project Development:

- *Right of Way Requirements:* Small footprint.
- *Siting Constraints*: None identified.
- *Retrofit Potential:* High potential to improve existing EDBs without physically modifying the basin.
- *Construction*: Access to the chemical storage facility will be needed for deliveries. Need enough head for mixing.

Advantages:

- Effective dose for anionic PAM is 3 to 50 times less than inorganic flocculants such as alum and ferric chlorides.
- Treating storm water with PAM does not require power or mechanical dosing equipment.
- Anionic PAM produces a large, stable floc, which settles much more rapidly than floc generated from voluminous metal hydroxides that are very difficult to dewater.
- PAM works over a very wide range of pH values, while inoragnic flocculants are pH-sensitive and must be adjusted to be effective. Inorganic flocculants consume alkalinity and lower system pH, while PAM has a negligible effect on system pH.
- When collected, pond sediments may be used as road fill or taken to disposal sites where excavated (clean) soils are usually deposited. These options assume that the concentrations of metals and other contaminants associated with sediments are low enough to be disposed of in these conditions.

Constraints:

- PAM dissolves very slowly before reaching full hydration and activation. Polymer activation is also a critical step that requires appropriate mixing. PAM must be added to storm water where turbulence is high enough to simulate a rapid-mix system.
- Aqueous PAM concentrations are limited to about 3% active ingredient because viscosity increases so rapidly.
- An odorless, free-flowing crystalline called acrylamide (AMD) is a chemical intermediate in the production and synthesis of PAM. AMD is regulated under National Primary Drinking Water Regulations, CFR 141.32(e)(23). To ensure compliance, it will be necessary to estimate AMD concentrations in the pond effluent and in the groundwater at sites where infiltration occurs.

Sources:

- PAM Research Project Washington State Department of Transportation (WSDOT). http://www.wsdot.wa.gov/eesc/environmental/pam.htm. April 2000.

Literature Sources of Performance Demonstrations:

- McElhiney M. & Osterli P. An Integrated Approach for Water Quality: The PAM Connection, West Stanislaus HUA, CA , Managing Irrigation-Induced Erosion and Infiltration with Polyacrylamide. University of Idaho Miscellaneous Publication No.101-96, 1996.
- Solka R.E & Lentz R.D. A PAM Primer: A brief history of PAM-related issues, Managing Irrigation-Induced Erosion and Infiltration with Polyacrylamide. University of Idaho Miscellaneous Publication No.101-96, 1996.
- Washington State Department Of Transportation (WSDOT). "Polyacrylamide (PAM) for Soil Erosion & Flocculation of Stormwater Detention Ponds at Highway Construction Sites." WSDOT High Runoff Manual, Section 4.4: WSDOT Experimental BMP-Quality Assurance/ Quality Control Plan. WAC 173-270-030.6.a.

BMP Fact Sheet
Detention Basin Outlet Improvements – Filters

Description:

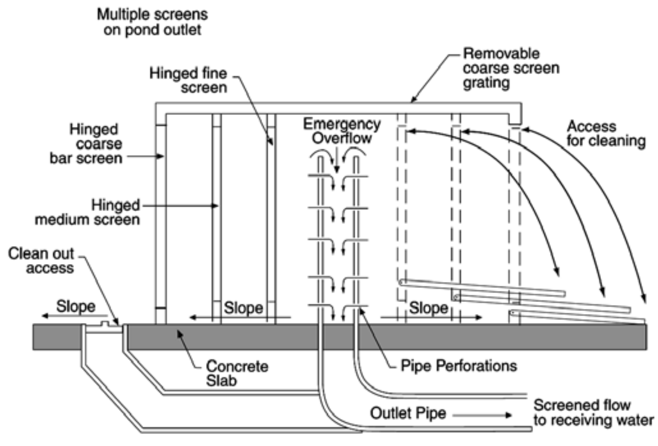
The improved screening outlet BMP consists of placing a three-screen system before or around the effluent discharge location in a sedimentation pond. Debris that does not settle out will be retained or removed from the pond effluent. The outlet consists of a perforated vertical pipe with an open end. If inflow greatly exceeds outflow and the pond water level rises, the excess water can spill over into the open end of the pipe. The three screens consist of an exterior coarse bar screen, an intermediary medium-sized screen, and an interior fine screen. The system is designed to catch debris on the screen before effluent is discharged from the sedimentation basin. The first screen filters larger and coarser materials such as trash; the second stops medium-sized solids and debris; the third may remove some suspended solids. Use of filter fabric at a pond outlet is not recommended because it will clog too rapidly. The three screens are designed in a box-like arrangement with the sides of the box hinged at the bottom to allow the screen "wall" to be lowered for cleaning. The multiple-screen box has a built-in emergency overflow arrangement consisting of pipe perforations and the open end of the vertical outlet pipe. If inflow significantly exceeds outflow and the pond water level rises, the water will spill over and flow into the open end of the pipe when the water level reaches the top of the vertical pipe. The system includes a cleanout connection for rodding or use of a "sewer snake" to remove blockages or buildup in the outlet pipe.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	◒	○
TDS	○	○

Caltrans SWMP Category:

Category III



Section View

Notes:

- Suspended solids and other constituents attached to the solids settle out in the pond. Heavy metals that are not dissolved but attached to particles might be removed with the settled solids.
- No performance data encountered in literature

Key Design Parameters:

1. Hydraulic design of perforated pipe outlet.
2. Screen sizes and mountings.

<u>Ancillary Facilities</u>

Extended detention basin

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Routine maintenance may include periodic debris removal.
- *Nuisance Control:* None associated with screens themselves.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove debris by spraying the screens in reverse flow.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively small.
- *Siting Constraints*: Requires adequate space at pond outlet for screen installation.
- *Retrofit Potential*: Screens are to be placed at effluent of existing sedimentation ponds.
- *Construction:* No issues identified.

Advantages:

- The improved screening outlet, like the original screen, would prevent clogging of the basin outlet as well as provide additional pollutant removal to the detention basin effluent.

Constraints:

- Clogging of the screens is common.

Sources:

- None available.

Literature Sources of Performance Demonstrations:

- Barrett, M.E., Malina, J.F., Jr., and Charbeneau, R.J., An Evaluation of the Performance of Geotextiles for Temporary Sediment Control, Water Environment Research, Vol. 70, No. 3, pp. 23-90. 1998.

Description:

Below grade storage are storm water detention systems using subsurface piping. Detained water can be reused or drained to the storm sewer or surface drainage.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

•

Key Design Elements:

1. Cover requirements
2. Storage capacity
3. Class V injection well determination if designed to infiltrate

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▗	○

● High ◒ Medium ○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Unknown
- *Nuisance Control:* Required to completely drain.
- *Traffic Control*: Unknown
- *Staffing/Equipment:* Likely vactor equipment with the ability to clean horizontal lines. Equipment and training needed for confined space entry.

Project Development:

- *Right-of-Way Requirements*: Large area requirements, but area above grade can be used if constructed properly.
- *Siting Constraints*: A minimum cover requirement in a non-traffic installation site is 12" (top of pipe to the top of grade). If traffic is present with a flexible pavement the minimum cover is 12" (top of pipe to the bottom of bituminous) for a pipe up to 36" in diameter, and 24" (top of pipe to the bottom of bituminous) for a pipe of 42"-60" in diameter. If traffic is present with a rigid pavement the minimum cover is 36" (top of pipe to top of pavement) for a pipe up to 36" in diameter, and 24" (top of pipe to top of pavement) for a pipe of 42"-60" in diameter.
- *Retrofit Potential*: Requires extensive excavation and backfill.
- *Construction:* Backfill requirements state that all retention and detention systems shall be installed in accordance with ASTM D 2321. Acceptable backfill material for the pipe embedment zone shall be class I and II as predicated in ASTM D 2321. Filter fabric is recommended around the entire installation to prevent migration of fines with retention systems.

Advantages:

- Subsurface retention/detention systems use available land efficiently while introducing low maintenance costs and posing little or no aesthetic problem.

Constraints:

- Difficult to clean out due to the fact that it is buried.
- Standing water may create mosquito habitat.

Sources:

- Advanced Drainage Systems, Inc., www.ads-pipe.com
- Contech Construction Products Inc. www.contech-cpi.com
- Lane-Enterprises, www.lane-enterprises.com
- StormTrap™, DoubleTrap™, www.stormtrap.com

Literature Sources of Performance Demonstrations:

- None available

Description:

This BMP consists of chemical disinfection of storm water using hypochlorous acid solution. The product of concentration (C) and contact time (t) may be adjusted to achieve various levels of disinfection as defined by the U.S. EPA. This process has proven successful for many years at inactivating pathogens and other microbial contaminants in drinking water and wastewater. The hypochlorous solution is to be injected at the end of the pipe before the baffled contact chamber or existing sedimentation basin. A chemical storage tank and chemical feed system capable of adjusting feed based on pipe flow is required. Hypochlorous acid dosing sufficient to achieve the desired Ct value is necessary. A contact chamber will be designed to achieve desired Ct value at high flows. Chlorine residual will be monitored. Dechlorination may be needed prior to discharge to receiving waters.

Constituent Removal:

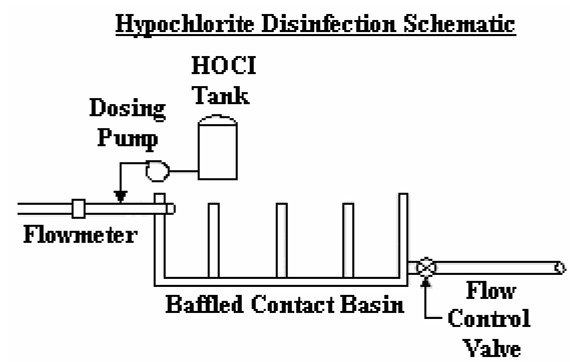
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	●	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness
- Some organics may be converted to other (possibly more harmful) products.

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Chlorine dose and contact time (Ct).
2. Chemical feed and storage facilities.
3. Mixing facilities.

Ancillary Facilities

Pretreatment to remove particles is required to achieve reliable disinfection. This will normally require sedimentation and filtration facilities upstream. Contact time must be provided in a contact basin of sedimentation basin downstream. Dechlorination system.

Equivalent Uniform Annual Costs:

	Cost Efficiency	*Level-of-Confidence*
EUAC	◳	◒

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Mechanical equipment must be maintained.
- *Nuisance Control:* None identified.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* Trained staff is required for mechanical equipment maintenance. Requires flow measurement device designed for a large range of flow conditions.

Project Development:

- *Right-of-Way Requirements*: Space requirements will depend on size of contact chamber needed to accommodate design flow.
- *Siting Constraints*: Restricted to sites with available nearby power.
- *Retrofit Potential*: Has potential to be used with existing sedimentation basins.
- *Construction*: Substantial excavation is needed.

Advantages:

- Specific use guidelines available and proven effectiveness on microbial contaminants.
- Insect vectors not an issue with chlorinated water.

Constraints:

- Harmful to receiving water biota.
- Formation of disinfection by-products (DBPs).
- Pre-treatment (e.g., removal of suspended solids) required in most cases.
- Requires special handling procedures and chemical storage tank on site.
- Substantial excavation is needed.
- May require special permitting and discharge water quality monitoring.
- May result in unnatural looking conditions in earthen basins.

Sources:

- www.jajagroup.com
- www.ionics.com

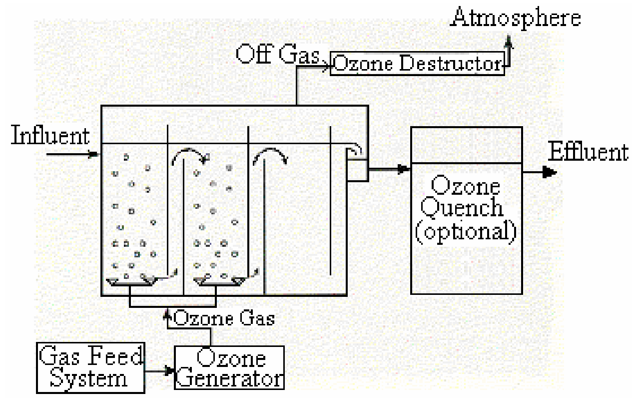
Literature Sources of Performance Demonstrations:

- None available.

Description:

Ozone is used in water treatment for disinfection and oxidation. An ozone treatment system has four basic components: a gas feed system, an ozone generator, an ozone contactor, and an off-gas destruction system. The gas feed system provides a clean, dry source of oxygen to the generator. The ozone contactor transfers the ozone-rich gas into the water to be treated, and provides contact time for disinfection (or other reactions). The final process step, off-gas destruction, is required as ozone is toxic in the concentration present in the off-gas. A quench chamber to remove ozone residual in solution may also be added to the treatment train.

The ozone feed system uses air, high purity oxygen, or a mixture of the two. Ozone systems are most applicable for continuous flow. For wet weather intermittent flow, a water sensor will be needed to start the ozone generator, but the first flush of the runoff would not be treated unless an equalization/storage basin is provided.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	●	◒
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- The bacterial loads in the water upon leaving the contact chamber (City of Malibu, California Bioxide Technology) have been reduced to allowable U.S. EPA "recreational use" limits.
- Constituent removal assumed to at least be as good as EDB because it is assumed to be used in conjunction with and EDB.

Key Design Elements:

1. Ozone dose and contact time (Ct).
2. Gas feed and ozone production equipment.
3. Contact facilities.
4. Quench tank.

<u>Ancillary Facilities</u>

Pretreatment to remove particles is required to achieve reliable disinfection. This will normally require sedimentation and filtration facilities upstream. Contact time must be provided in a contact basin of sedimentation basin downstream.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	◳	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Generators should be checked daily when in operation. Manual start-up of the ozone generator is preferable since it needs to be purged before each start-up. Filters and desiccant in air preparation systems should be changed periodically.
- *Nuisance Control*: None.
- *Traffic Control*: No issues identified.
- *Staffing/Equipment:* The ozone system operation is to be performed by an operator with a water treatment background. Maintenance on the generators requires skilled technicians. This work can also be done by the equipment manufacturer if trained maintenance staff is not available.

Project Development:

- *Right-of-Way Requirements:* Relatively small footprint.
- *Siting Constraints*: Restricted to sites with available nearby power.
- *Retrofit Potential*: Most suited for maintenance stations.
- *Construction**:*** The ozone diffusers can easily be damaged by debris and sediments. The pre-treatment step will have to remove most of the sediments as well as the oil and grease. Accumulation of sediments in the contact chamber should be avoided.

Advantages:

- Ozone is a strong disinfectant and has a limited number of by-products.
- Low doses are required to complete disinfection.
- The process does not provide residual ozone concentration in the treated effluent. This will then minimize the impact on the receiving watershed.
- Even though ozone systems are complex, using highly technical instruments, the process is highly automated and very reliable.

Constraints:

- The ozone must be produced on site because it cannot be stored.
- Ozonation technology has a very high energy requirement.
- Some ozonation by-products may be harmful to the receiving water.
- In the presence of many compounds commonly encountered in water treatment, ozone decomposition forms hydroxyl free radicals.
- Ozone escaping to atmosphere may contribute to air pollution problems.

Sources:

- EPA Guidance Manual, Alternative Disinfectants and Oxidants, April 1999.
- Bioxide Corporation, Vanguard Stormwater Treatment System, http://www.bioxide.com/water.htm.
- PCI-Wedeco Environmental Technologies, Inc. One Fairfield Crescent, West Caldwell, NJ 07006.

Literature Sources of Performance Demonstrations:

- The City of Malibu, California, approved the use of Bioxide's technology to treat their runoff before it reaches the lagoon near the beach for a "dry-flow" run.

Description:

Ultraviolet (UV) light disinfects water by altering the genetic material (DNA) in the cells so bacteria, viruses and other microorganisms can no longer reproduce or infect. In UV disinfection systems, the light is produced by germicidal lamps (200 to 300 nanometers) enclosed in a pressure vessel or submerged in a water channel. As the water flows past the UV lamps, the microorganisms are exposed to a lethal dose of UV energy. The UV dose is the product of the light intensity and contact time.

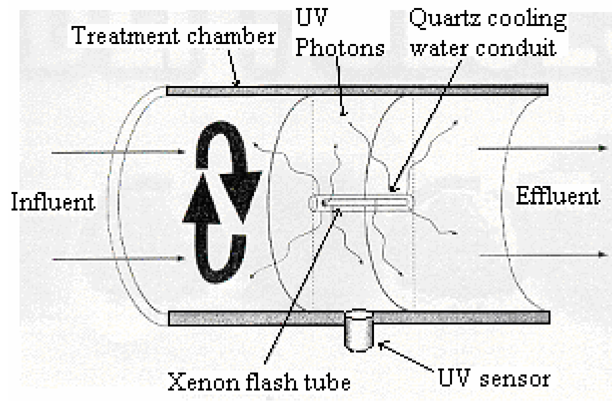
The UV disinfection treatment is an in-line device downstream of another treatment process. Potential applications could be: As an in-line pipe after a litter/coarse material removal device such as a vortex separator; downstream of a BMP such as a multiple chamber treatment train (MCTT); sedimentation basin or media filter.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	●	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Efficiency does not include required pretreatment.
- Removal efficiency depends on the UV dose applied to storm water.
- Factors affecting disinfection efficiency by UV light include: turbidity or suspended solids in the water, light-absorbing characteristics of the water, flow distribution across the UV lamps, contact time of water with UV light.
- Presence of some compounds in the storm water may reduce UV efficiency such as: dissolved or suspended matter may shield microorganisms from UV radiation, high turbidity of surface water can impact disinfection efficiency. Some chemical substances can decrease UV transmission. Color also reduces transmission within a UV contactor.



Caltrans SWMP Category:

Category III

Key Design Elements:

1. Light intensity and contact time.
2. Hydraulic system for moving water past lamps.
3. Facilities for cleaning lamps.

<u>Ancillary Facilities</u>

Pretreatment to remove particles is required to achieve reliable disinfection. This will normally require sedimentation and filtration facilities upstream.

Equivalent Uniform Annual Costs:

	Cost Efficiency	*Level-of-Confidence*
EUAC	◲	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Each lamp must be cleaned periodically – typically every two weeks for wastewater discharges, but probably less frequently for intermittent storm water discharges. Pumps must be maintained.
- *Nuisance Control:* None identified.
- *Traffic Control*: None identified.
- *Staffing/Equipment:* Highly trained staff is required for mechanical equipment maintenance.

Project Development:

- *Right-of-Way Requirements*: May be compact if pretreatment is not required.
- *Siting Constraints*: Restricted to sites with available nearby power. Access is required.
- *Retrofit Potential*: Moderate potential.
- *Construction:* Significant start-up and testing requirements.

Advantages:

- Natural process that disinfects without chemicals.
- Low maintenance requirements.
- Automated operations and controls.
- Compact system, small footprint.
- Suitable for retrofit to existing facilities.
- No impact on other processes following UV treatment.
- UV disinfection can meet water quality standards that have stringent requirements for total and fecal coliform (from 2 to 200 MPN/100ml) without generating disinfection by-products (DBPs) or handling chemicals.

Constraints:

- No chemical residual.
- Pretreatment requirement may be substantial. Clumping microorganism and turbidity can impact disinfection by harboring pathogens in the aggregates.
- Specific design parameters vary for individual waters (UV transmittance).
- Under certain conditions, some organisms are capable of repairing damaged DNA and reverting back to an active state to reproduce again (photoreactivation). This can be minimized by shielding the process stream or limiting the exposure of disinfected water to sunlight immediately following disinfection.
- Organic and inorganic fouling usually occurs on UV lamp sleeves. Inorganic fouling, which is related to the high temperature of the lamp, is the most difficult to clean because inorganics such as iron and manganese bind to the quartz sleeve.

Sources:

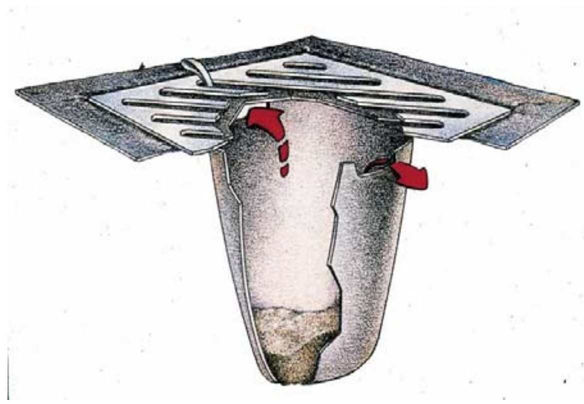
- PCI-Wedeco Environmental Technologies, Inc. One Fairfield Crescent, West Caldwell, NJ 07006

Literature Sources of Performance Demonstrations:

- Barrett, M. E. & J. F. Malina Jr. Stormwater Disinfection Research Work Plan. Center for Research in Water Resources: University of Texas, Austin. June 1999.
- EPA Guidance Manual, Alternative Disinfectants and Oxidants. April 1999.

Description:

Fabric inserts consist of a fabric filter sock installed under the storm grate to catch oil, grease, sediment, litter, and debris. The devices are simple, inexpensive, and easy to install and replace. They are ideal on construction sites, industrial facilities, and parking lots. The fabric sock must be sized to the storm grate. The fabric material and shape is dependent upon the types of contaminants present at the site.



Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Key Design Elements:

1. Proprietary devices.
2. Hydraulic capacity and pollutant storage capacity.
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged.

<u>Ancillary Facilities</u>

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	▖	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: The inserts need to be checked regularly during the rainy season to prevent clogging. The socks may fall into the basin if too fully loaded. The socks will become heavier as they fill with contaminants, making them more difficult to remove. Care should be taken when removing the insert for replacement/cleaning so that the contaminants do not fall into the drain.
- *Nuisance Control:* None identified.
- *Traffic Control*: If located along a shoulder or median, maintenance activities may require traffic control.
- *Staffing/Equipment:* It may be a challenge for one person to lift up the storm grate and remove a full sock beneath it.

Project Development:

- *Right-of-Way Requirements*: Same as drop inlets.
- *Siting Constraints*: Requires a storm water inlet.
- *Retrofit Potential*: Easy to add to any inlet.
- *Construction*: No issues identified.

Advantages:

- The device can be easily retrofitted, is simple to install and maintain, and it is reusable. Some designs have a Pop-Up Capacity Indicator that alerts maintenance personnel that the sock needs to be replaced or emptied.

Constraints:

- If the socks become too filled with contaminants, they may be difficult to lift out of the drain to clean/replace.
- Excess debris may affect drain inlet capacity.

Sources:

- Catch-All, Marathon Materials, www.marathonmaterials.com
- Drain Diaper (Petro-Marine, Inc.), http://www.petromarinecompany.com/petro-marine/noname.html
- DrainPacTM (PacTec, Inc.).
- Drain Guard, (Gullywasher), www.gullywasher.com
- Drain Web, (Gullywasher), www.gullywasher.com
- Drain Gate, (Gullywasher), www.gullywasher.com
- Geotextile Catch Basin Insert (Gullywasher), http://www.gullywasher.com/geoso.html
- Ultra-Drain Guards (UltraTech International), http://www.stormwater-products.com/
- www.usabluebook.com

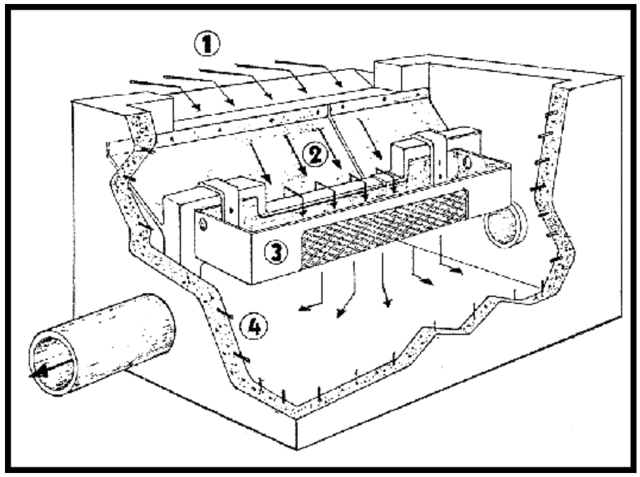
Literature Sources of Performance Demonstrations:

- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/ultradrainguard.html

BMP Fact Sheet
Drain Inlet Inserts – Flow-Through Baskets

Description:

Flow-Through Baskets are wire catchbaskets that are installed in storm drains. Their main function is to catch sediment, litter, and organic debris. They are relatively easy to install, durable, and require low maintenance. Flow-through baskets can be installed at any curb inlet, including those located at construction sites and park-and-ride areas. The flow-through baskets can be simply designed for various capacities and can contain a variety of mesh size openings. For larger capacities, more space is required. The size of the debris must be estimated accurately so that the wire mesh can be sized accordingly. The amount of debris will affect how large to make the basket, so more or less space will be required to fit the device.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	◒
BOD	○	○
TDS	○	○

Notes:

- AquaShieldTM SD-100: Chattanooga, TN Stormwater Management Division accepts device based on a report from the Analytical Industrial Research Laboratories, Inc. dated September 24, 1977 and the U.S. Department of the Navy, Department of Commerce, and Best Manufacturing Practices Center of Excellence (BMPCOE) determines that it meets industry submitted practice requirements; DrainPacTM: Soper, Spencer, Encinitas Installs New Storm Drain Filters, North County Times, January 6, 2000.
- DrainPacTM: Bourelle, Andy, Tahoe Keys Installs DrainPacsTM, *Tahoe Tribune*, November 5, 1999; Grate Inlet Skimmer Box: Happel, Tom, Reedy Creek Report 3, December 23, 1999; many field tests have been performed, but not officially published.

Caltrans SWMP Category:

Category III

Key Design Elements:

1. Proprietary devices.
2. Hydraulic capacity and pollutant storage capacity.
3. Provision for overflow or bypass to avoid flooding when the insert is full or clogged.

Ancillary Facilities

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▖	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Needs to be frequently inspected and cleaned if needed. If there is heavy rainfall, more maintenance is required. If the baskets get too full, they may be difficult to clean.
- *Nuisance Control:* None identified.
- *Traffic Control*: If located along a shoulder or median, maintenance activities may require traffic control.
- *Staffing/Equipment:* There are several methods to clean: manually retrieve basket, manually use specially designed basket liners, or vacuum. The gross pollutants do not need to be handled during cleaning. The filter screens can be easily removed. There is no risk with confined space entry regulations, and there is no risk to public safety and health.

Project Development:

- *Right-of-Way Requirements*: Minimal requirements.
- *Siting Constraints*: Requires a storm water inlet.
- *Retrofit Potential*: Easy to add to any inlet.
- *Construction:* No issues identified.

Advantages:

- There is a range of sizes that can be retrofitted to storm drain requirements. They are easy to install and clean. Maintenance can be simple and quick. Adsorption booms can be attached.

Constraints:

- If there is heavy rainfall, more maintenance is required.
- If the baskets get too full, they may be difficult to clean.
- Debris and litter may quickly exceed drain inlet insert capacity.
- Depending on how large the basket will be, more land will have to be excavated, so there cannot be pipes, lines, etc. at the location.
- Possibility of clogging and causing local flooding.

Sources:

- Curb Inlet Basket (CIB) (Suntree Technologies, Inc.), http://www.suntreetech.com/catalog1/page6.html
- Ecosol RSF 100/GSP (Ecosol), http://www.ecosol.com.au/
- Fossil Filter™ Flo-Gaurd High Capacity Insert System (KriStar Enterprises), http://kristar.com/level2/products/hicap.html
- Stream Saver Catch Basin Inserts (Zymark, Inc.),
- Stream Saver Bio-Oil Filter Insert (Zymark, Inc.),
- Verti-Pro Vertical Catch Basin Protection (Alpine Stormwater Mgt. Co.)
- Wire Catch Basin Inserts for Litter, Oil & Sediment Control (Gullywasher) http://www.gullywasher.com

Literature Sources of Performance Demonstrations:

- None identified.

Description:

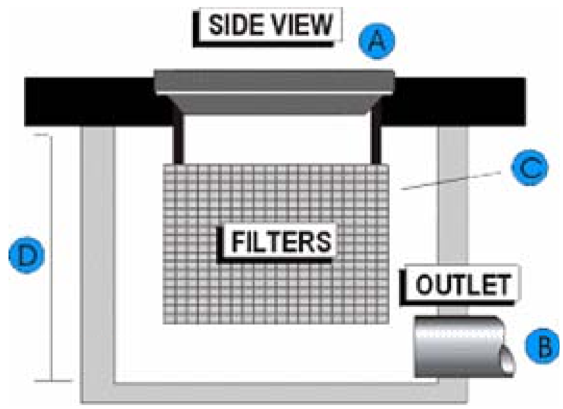
Flow-through boxes are a type of technology that catch sediment, debris, and organic litter in internal baskets or bags and remove contaminants by filtration media (sorbent). Filtration can vary to suit the source of contaminants. Wastewater flows by gravity (or can be pumped into a mobile unit) into the primary sediment removal stage to capture and extract unwanted debris and suspended solids. The wastewater then moves through a series of filters. The devices can be used by industrial, commercial, governmental, institutional and multi-family facilities, especially in vehicle parking lots, corporation yards, service stations, etc. These devices require regular maintenance for proper performance.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	◒	○
Pesticides	◒	○
Total Metals	●	◒
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	●	◒
TDS	○	○

Notes:

- AquaShieldTM SD-100: Chattanooga, TN Stormwater Management Division accepts device based on a report from the Analytical Industrial Research Laboratories, Inc. dated September 24, 1977 and the U.S. Department of the Navy, Department of Commerce, and Best Manufacturing Practices Center of Excellence (BMPCOE) determines that it meets industry submitted practice requirements; DrainPacTM: Soper, Spencer, Encinitas Installs New Storm Drain Filters, North County Times, January 6, 2000.
- DrainPacTM: Bourelle, Andy, Tahoe Keys Installs DrainPacsTM, *Tahoe Tribune*, November 5, 1999; Grate Inlet Skimmer Box: Happel, Tom, Reedy Creek Report 3, December 23, 1999; many field tests have been performed, but not officially published.



Caltrans SWMP Category:

Category III

Key Design Elements:

1. Provision for overflow or bypass to avoid flooding when the insert is full or clogged.

Ancillary Facilities

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	◳	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: The adsorption media must be removed and disposed of properly and frequently. It is a good idea to broom sweep around the area of the inlet. Trapped, solids, debris, and foreign matter must be removed to prevent restrictions and blockage. A high holding capacity will require less maintenance. Fastening devices should be regularly inspected. Proof of maintenance may be required due to past abuses in installed storm water treatment devices.
- *Nuisance Control:* Can pool water if clogged.
- *Traffic Control*: If located along a shoulder or median, maintenance activities may require traffic control.
- *Staffing/Equipment:* Some manufacturers provide maintenance services. The larger size generally requires removal of sediment from the device with a vacuum truck.

Project Development:

- *Right-of-Way Requirements*: Same as drop inlets.
- *Siting Constraints*: Requires a storm water inlet.
- *Retrofit Potential*: May be added to most inlets.
- *Construction*: It may be difficult to install device (drill, fasten, etc.) if storm drain area is small. Seal around filter housing to prevent water from bypassing filter. A watertight assembly of the product is important.

Advantages:

- The devices can be installed relatively easily in new and existing facilities without much structural modification.
- There are options to install fine sediment screens.
- The filtration media type and amount can be varied.
- Normal storm water flow is not usually restricted.
- Some devices are constructed to allow for easy NPDES sampling. Other devices have a "trap" for floatables.
- Installation can be permanent or temporary.
- Baffle configurations can also be installed in the system.
- Servicing the device does not typically take long (under 15 minutes).

Constraints:

- The adsorption media has to be removed and disposed of properly periodically during the storm season.
- If media become saturated, pollutants will pass through freely.
- May be difficult to clean filter baskets/bags.
- Clogged filter baskets will hinder flow and possibly flood roadway.
- Efficiency is proportional to maintenance.
- May have to install standpipe in existing drain inlet or replace a basin that is too small.

Sources:

- AquaShieldTM SD-100 (Remedial Solutions, Inc.) http://wwwremedialsolutions.com/aqua_shield/ index.html
- BMP Filter "CB" Series (StormWater Compliance International).
- CLR Filter (Stormwater Systems, Inc.).
- Grate Inlet Skimmer Box (Suntree Technologies, Inc.) http://suntreetech.com
- Grate Protector 1000 & Grate Protector 2000 (Suntree Technologies, Inc.) http://suntreetech.com
- Hydrocartidges Storm Drain Filtration System (Advanced Aquatic Products Int'l, Inc.).
- HydroKleen (Hydro Compliance Management, Inc.).
- Oil and Sediment Trap for Catch Basins (Gullywasher).
- SIFT Filter (REM Environmental Marketing), StormKlenz (Best Management Technologies).
- Trench Drain Systems (Gullywasher), http://www.gullywasher.com
- Ultra-Urban Filter (AbTech Industries).

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Media Filters use filter media exclusively in various configurations to trap contaminants found in storm water runoff. The system is easy to install, cost effective and easy to maintain. It can be used in parking lots and service bays. The device must be sized to fit the drain inlet. System sizing should be either volume-based or flow-based. The proper filter must be used to effectively remove contaminants.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	◒
Nutrients	●	○
Pesticides	●	○
Total Metals	◒	◒
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Caltrans SWMP Category:

Category III

Tee Section Filters for Manholes

Key Design Elements:

1. Proprietary devices.
2. Media type and depth.
3. Hydraulic capacity and pollutant storage capacity.
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged.

Ancillary Facilities

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▖	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Filters must be regularly inspected and changed periodically depending on the storm season events. May require closed-space entry.
- *Nuisance Control*: Water can pool if clogged.
- *Traffic Control*: Commonly located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment*: Not available.

Project Development:

- *Right of Way Requirements*: Same as drop inlets.
- *Siting Constraints*: Requires a storm water inlet.
- *Retrofit Potential*: Easy to add to most inlets.
- *Construction*: Confined space situations may be an issue.

Advantages:

- The system is easy to install.
- The device can be installed in parallel to increase treatment capacity.
- Water can pass through freely (if void of solids).
- Some filter cartridges can be recharged.
- Filter media can easily be site-specific.
- Some devices are delivered precast.

Constraints:

- Media Filters do not remove and catch debris, litter, etc, effectively, if at all. Solids traps must be installed for this purpose or else collected from the bottom during low flow.
- Media should be kept dry between storm events to extend life.
- Potential for clogging and flooding road.

Sources:

- Drop-In-Drain-Interceptor (Robert's Design Incorporated).
- Multi-Cell Filter (Best Management Technologies).
- Radial Filter Cartridge Filtration System (Gullywasher) http://www.gullywasher.com/radial08.html
- Raynfiltr™, Enviromental Filtration, Inc.
- Removable Baffle Stormwater Treatment System (Gullywasher) http://www.gullywasher.com/baffle1.html
- StormFilter® (StormWater Management, Inc.) http://www.stormwatermgt.com/products/stormfilters.html
- Tee Section Filters for Manholes (Gullywasher) http://www.gullywasher.com/tee1.html

Literature Sources of Performance Documentation:

- None identified.

Description:

Passive Skimmers float directly on the water surface and absorb floating hydrocarbons. The hydrocarbons are transformed into manageable solid waste. It is an inexpensive and simple method of capturing hydrocarbons. Passive Skimmers generally float in storm water catch basins, sumps, vaults, holding tanks, and oil/water separators. The skimmers must be able to withstand turbulent environments. The absorbent material should be specific to the contaminants at a location.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- This device removes floatables.
- OARS Passive Skimmer: Co-polymer meets the non-leaching criteria developed by Washington state's King County Surface Water Management Division (Oil Leachate Test for Adsorbent Filter Media, April 1995) for products used in nonpoint source pollution control; Passive Skimmer: helps comply with NPDES, 40 CFR 122.26 (1999).
- OARS Passive Skimmer: successfully passed the EPA Method 1311/TCLP (Toxicity Characteristic Leaching Procedure) Test for volatile and semi-volatile organics and the 8 RCRA metals

Caltrans SWMP Category:

Category III

Key Design Elements:

1. Proprietary devices.
2. Adsorbent material.
3. Provision for overflow or bypass to avoid flooding when the insert is clogged.

Ancillary Facilities

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Must be regularly inspected. Maintenance consists of pulling the skimmer out and replacing it.
- *Nuisance Control:* None identified.
- *Traffic Control*: Commonly located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* Minimal training required.

Project Development:

- *Right of Way Requirements*: Same as drop inlets.
- *Siting Constraints*: Requires a storm water inlet.
- *Retrofit Potential*: Easy to add to any inlet.
- *Construction*: Simple installation.

Advantages:

- Skimmers are cost effective.
- They "lock up" absorbed hydrocarbons and will not leak or leach, so they can remain in place for long periods.
- They continually absorb.
- Maintenance is quick and easy.
- Requires no structural modifications to existing drainage structures or oil/water separators.

Constraints:

- Some skimmers may contribute to sediment clogging.
- Skimmers only trap hydrocarbons, and do not contribute to sediment control.
- If a skimmer has adsorbed to its maximum capacity, hydrocarbons will not be captured until the device is replaced.

Sources:

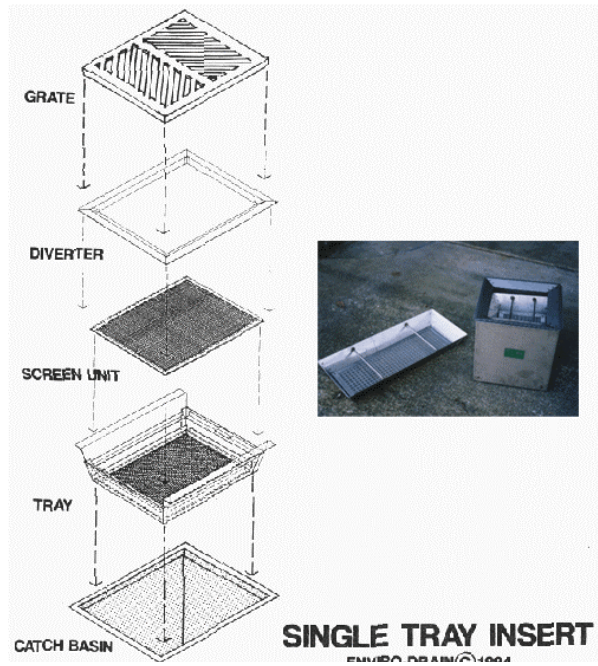
- OARS Passive Skimmer (AbTech Industries) http://www.abtechindustries.com/Passive%20skimmer.html
- Passive Skimmer (UltraTech International)
- http://www.stormwater-products.com/

Literature Sources of Performance Documentation:

- None identified.

Description:

Trickle Down Trays consist of levels of trays that have different purposes in treating storm water. Usually, contaminated water enters through a grate and is diverted to the first tray, which removes sediments, litter, and organic debris. Next, the water trickles down to a second tray that contains an absorbing media to remove hydrocarbons. Additional trays can be added to serve different purposes, such as activated carbon that can absorb fertilizers and pesticides. These systems are versatile and can be used in parking lots, streets, driveways, industrial facilities, and municipalities. Several trays could be designed to meet a variety of decontamination needs. Various mesh sizes will determine flow rate, maintenance, and rate of pollutant removal. It must be made of durable material to withstand potentially harsh conditions.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

- See: Enviro-Drain(R), Inc.: Savelle, Jon, Catching Water Pollutants at the Source, *Journal Environment*, September 15, 1998.

Key Design Elements:

1. Proprietary devices.
2. Media type and depth.
3. Hydraulic capacity and pollutant storage capacity.
4. Provision for overflow or bypass to avoid flooding when the insert is full or clogged.

Ancillary Facilities

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	◱	○

● High ◒ Medium ○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Must be regularly inspected and replaced. A multi-tray unit would be heavy when wet and with sediment.
- *Nuisance Control:* None identified.
- *Traffic Control*: Commonly located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* Minimal training required.

Project Development:

- *Right-of-Way Requirements*: Same as drop inlets.
- *Siting Constraints*: Requires a storm water inlet.
- *Retrofit Potential*: Easy to add to most inlets.
- *Construction:* No construction necessary.

Advantages:

- Trickle Down Trays can be tailored to suit the needs specific to a site.
- Many of the filters used are recyclable.

Constraints:

- Efficiency is proportional to maintenance.
- Litter can hinder flow and cause flooding.

Sources:

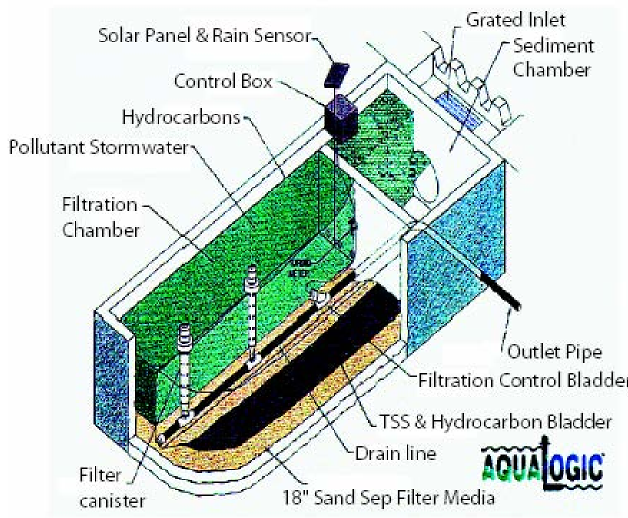
- Adjustable Skimmer Tray (Suntree Technologies, Inc.) http://www.suntreetech.com/page6.html
- CaptureFlow™, www.carsonind.com
- Enviro-Drain® (Enviro-Drain, Inc.) http://www.enviro-drain.com/

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Cartridge filters use canisters to hold media or fabric through which water is filtered. The AquaLogic is an example of a cartridge filter. The AquaLogic system consists of two chambers: a sedimentation chamber and a filtration chamber where cloth filter cartridges are placed. The AquaLogic system is entirely automated and self-sufficient, utilizing rain sensors, solar panels, batteries and an inflatable bladder. The pneumatic bladder located in the sedimentation chamber outlet drain is inflated when sensors detect rain. The bladder prevents the storm water from flowing into the filtration chamber right away and provides a set sedimentation time. When the pre-set sedimentation time is reached, the bladder deflates and the storm water is fed by natural hydraulic gradient flow into the cloth-wound media cartridge filters. The design volume for the sedimentation basin should be increased to account for reduction in storage volume due to deposition of solids. Stormwater Management also has a cartridge filter described in Appendix C-40.



Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- Removes up to 95% total suspended solids and 78% total petroleum hydrocarbons.
- The AquaLogic is approved by the Texas Natural Resource Conservation Commission (TNRCC) and the San Antonio Water Systems (SAWS).

Caltrans SWMP Category:

Category III

Key Design Elements:

1. Proprietary design.
2. Power requirements

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Potential high maintenance of the cartridge filter. Inspecting the facility after each storm and removing litter and sediment and all spent filter cartridges, repairing or replacing inoperative controls, valve or filter canister, and cleaning the filter cartridges and canister if necessary.
- *Nuisance Control* None identified.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* Crews must be trained to repair or replace any cartridge filter or part associated with the facility.

Project Development:

- *Right- of-Way Requirements*: Requires space and access.
- *Siting Constraints*: Must have sufficient hydraulic head.
- *Retrofit Potential*: Caltrans ROW space is typically limited, particularly in highly urbanized areas.
- *Construction:* None identified.

Advantages:

- Control of sedimentation time will improve water quality. No AC power requirement. Multiple-use capabilities: Parking spaces can be built on top of the system. Smaller footprint than for conventional sedimentation/gravity sand filter.

Constraints:

- Removal of fine sediment in cartridge filters is not as effective as in granular media filters.

Sources:

- Keblin, M.V., et al. The Effectiveness of Permanent Highway Runoff Controls: Sedimentation/Filtration Systems Center for Research in Water Resource. 1997.
- Roy, John R. AquaLogic Stormwater Abatement Filter System. SWAF, Inc- P.O. Box 701745, San Antonio, Texas 78270, Tel: (210) 602 8121. April 2000.
- StormFilter, Stormwater Management, www.stormwaterinc.com
- http://www.aqualogic.com/

Literature Sources of Performance Demonstrations:

- None available.

Description:
A Compressible Media Upflow Filter, one of such designed by Schriber Wastewater Treatment Technologies, is referred to as a Fuzzy Filter. A Fuzzy Filter is a packaged high-rate filter using fiber spheres in an upflow design. The Fuzzy Filter consists of extremely lightweight, synthetic fiber spheres that are 85% porous, which allow the filter to remove pollutants at high levels with minimal headloss. Filtration and water quality rates vary depending on the amount of compressed force applied to the filter media by a movable plate at the top of the media. The filter media bed is cleaned by lifting the plate off the bed, (which allows the bed to expand), then scouring the bed with air and water backwash. The wash water is passed from the filter to either a sewer line or a drying basin. The media is then recompressed by the filter plate forcing water through the media filter and flushing free any residual solids. After an allotted time, the cleaned effluent is allowed to exit to Fuzzy Filter System. A Fuzzy Filter could replace the sand filter chamber in the Austin filter design. The water from the sedimentation chamber would be directly pumped into the Fuzzy Filter package unit.

Constituent Removal:

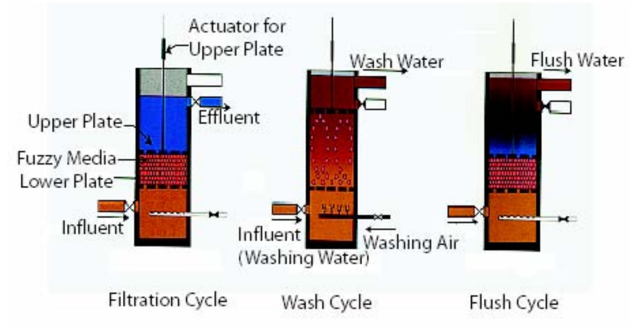
Constituent Group	Removal Efficiency	Level-of-Confidence
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in literature.

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Proprietary design.

<u>Ancillary Facilities</u>
Sedimentation facilities required upstream.
Backwash water storage and disposal facilities.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	Level-of-Confidence
EUAC	▝	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- Requirements: Removing plate bed, backwash with air and water, recompress media.
- Nuisance Control: None identified.
- Traffic Control: If located along a shoulder or median, maintenance activities will require traffic control.
- Staffing/Equipment: Residual handling, mechanical equipment breakdown.

Project Development:

- Right-of Way-Requirements: Requires a smaller footprint than a sand filter.
- Siting Constraints: Requires connection to sewer lateral or drying bed for backwash water waste stream. Requires connection to a water supply for backwashing or backwash water tank and pump.
- Retrofit Potential: Caltrans ROW space is typically limited particularly in highly urbanized areas.
- Construction: Traffic control may be required for retrofits if in close proximity to roadway.

Advantages:

- The main advantage of the Fuzzy Filter over a traditional sand filter is that this package unit requires a smaller footprint. Other advantages are: high flow rate, lower backwash water usage than sand filter and lower headloss than conventional sand filter.
- Backwashing cycle allows cleaning sediment from the filter media rather than excavating a portion of the media at the end of the season as required for slow sand gravity filters. Installation of filters possible where there is insufficient head for gravity filtration.

Constraints:

- Restricted to sites with available nearby power and possibly a sewer connection.

Sources:

- Schreiber Wastewater Treatment Technologies.

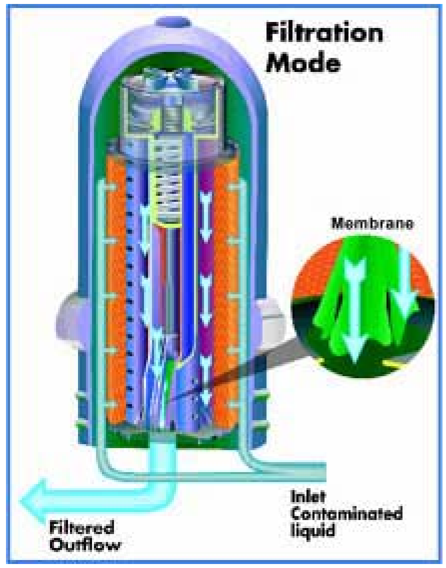
Literature Sources of Performance Demonstrations:

- Caliskaner O., Tchobanoglous G., Evaluation of the Fuzzy Filter for the Filtration of Secondary Effluent, Department of Civil and Environmental Engineering, University of California, Davis. September 1996.
- Fuzzy Filter: High Rate Filtration System. Schreiber Wastewater Treatment Technologies, http://www.schreiberwater.com/eqfuzzy.htm April 2000.
- Shepard, John. Cost Estimate. Fuzzy Filter: Compressible Media Filter Data. April 2000.

BMP Fact Sheet
Filtration – Disc

Description:

A Disc Filtration device, one of such designed by Arkal Filtration Systems/Zeta Technologies, is referred to as a Spin Klin. The Spin Klin self-backwashing disc filter was designed for filtration of solids from irrigation water, but may be applicable on pressurized pipes downstream of storm water sedimentation basins. The filter consists of a spring-loaded spine that holds a number of stacked, diagonally-grooved polyproplylene discs enclosed in a corrosion and pressure-resistant housing. The stacked discs create a filtration element with a statistically significant series of valleys and traps. During filtration, the discs are compressed by the spring and the differential pressure of the water, which flows from the peripheral end to the core of the element. Backwashing involves release of the compression spring and high-pressure flow of clean water through nozzles at the center of the spine. The discs spin free and solids are efficiently flushed out through the drain. Modular batteries allow for easy expansion of system in various space-saving configurations.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No long-term water quality monitoring studies have been discovered in literature to evaluate treatment effectiveness.
- No performance data encountered in literature.

Caltrans SWMP Category:

Category III

Key Design Elements:

Ancillary Facilities
Sedimentation facilities required upstream.
Backwash water storage and disposal facilities.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Power needed. Mechanical equipment maintenance.
- *Nuisance Control:* None identified.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* Crews would need to be trained to maintain equipment.

Project Development:

- *Right-of-Way Requirements*: Not Available.
- *Siting Constraints*: None identified.
- *Retrofit Potential*: Caltrans ROW space is typically limited particularly in highly urbanized areas.
- *Construction:* Needs pressurized pipe. Batteries of filters are heavy and would require equipment to move.

Advantages:

- Micron-precise filtration of solids. Claimed by the manufacturer to retain large amount of solids for long filtration cycles (Note: solids in irrigation water may differ from those of settled storm water). Low maintenance self-backwashing design. Self-contained.

Constraints:

- Removes only solids-associated contaminants. Limited application. Designed for installation on pressurized pipes. Not designed to remove larger solids so upstream sedimentation would be needed. May not be suitable for use at side of freeway.

Sources:

- Arkal Filtration Systems, Kibbutz Bet Zera, Jordan Valley, Israel. Tel: (972)-4-6775140; Fax: (972)-4-6775476; E-mail: filters@ arkal.com http://www.arkal-filters.com/

Literature Sources of Performance Demonstrations:

- None identified.

Description:

This idea consists of combining the sedimentation and filtration processes in one basin. This design concept is to improve the contaminant removal capabilities of an infiltration pond or Extended Detention Basin (EDB) by covering an unlined detention basin bottom with a filter media and filter fabric and possibly topping it with an adsorption layer such as GAC, IX resin, or both. The bottom of the basin would function like a filter and an adsorber if GAC or GAC/IX is used. Buried perforated pipes would be installed below the adsorption layer to convey filtered water away for disposal. The adsorption layer is separated from the filter media by a nylon or metal sieve and covered with a filter fabric to prevent clogging. Adsorbent "pillows or booms" are added to the top of the sedimentation basin to provide additional oil and grease removal.

Constituent Removal:

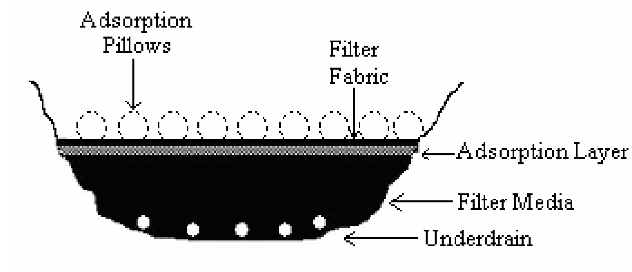
Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Caltrans SWMP Category:

- Category III



Key Design Elements:

1. Detention basin volume.
2. Filter area.
3. Media type and depth.
4. Filtered water collection system.

<u>Ancillary Facilities</u>
None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		○

● High ◒ Medium ○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Periodic regeneration or disposal of GAC, IX and sand is required. Potential clogging of the filter fabric is the main concern of this alternative. The filter fabric should be inspected regularly and replaced if necessary. Sediments deposited onto the media filter (or when the filter is clogged) will need to be removed and the media replaced.
- *Nuisance Control:* Clogged filters can produce standing water and provide breeding habitat for mosquitoes.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high.
- *Siting Constraints*: Adequate space required for relatively large footprint device.
- *Retrofit Potential*: Unlined detention basins can be retrofitted.
- *Construction*: Retrofits of existing detention basins will impact operations at the affected facility.

Advantages:

- Combining sedimentation/filtration and perhaps eventually infiltration in a single basin will improve effluent quality while still using the same footprint as an EDB.

Constraints:

- IX resin beads must be kept at a minimum humidity level. It is not clear at this point how this issue should be addressed.
- The clogging rate of the filters unknown.

Sources:

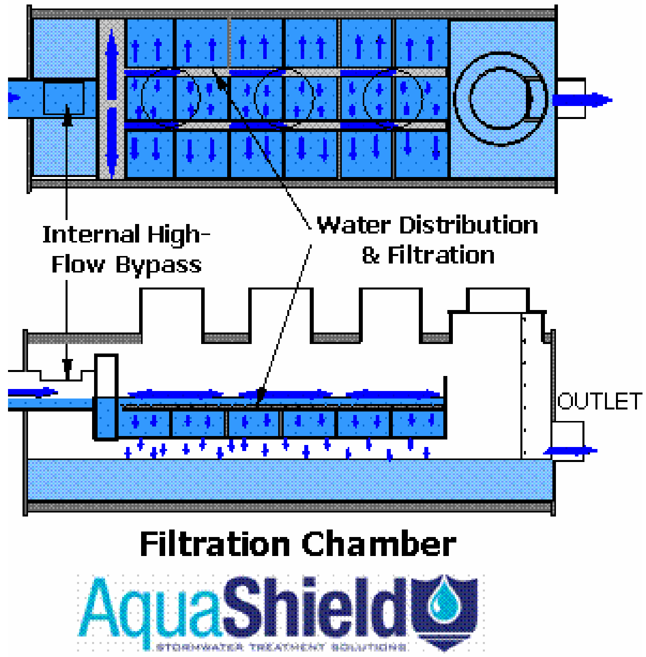
- None available.

Literature Sources of Performance Demonstrations:

- No information available.

Description:

This idea consists of combining the sedimentation and filtration processes in one vault. This design concept is to improve the contaminant removal capabilities of vault type BMPs (Water Quality Inlets and Hydro-dynamic Separators) The Aqua-Filter™ system is designed with a filter bed suspended in a vault. Water flows through the media and drains down into the vault. It appears the Aqua-Filter™ holds a permanent pool of water in the vault.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	◒
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	○
BOD	○	○
TDS	○	○

Notes:

- AquaShield manufacturer recommends Swirl Concentrator for upstream pre-treatment.

Key Design Elements:

1. Detention basin volume.
2. Filter area.
3. Media type and depth.
4. Filtered water collection system.

Ancillary Facilities

None.

Caltrans SWMP Category:

- Category III

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	◲	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- Requirements: Periodic regeneration or disposal of filter media is required. Potential clogging of the filter fabric is the main concern of this alternative. The filter fabric should be inspected regularly and replaced if necessary. Sediments deposited onto the media filter (or when the filter is clogged) will need to be removed and the media replaced.
- *Nuisance Control:* Standing water in the vault can provide breeding habitat for mosquitoes.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high.
- *Siting Constraints*: Adequate space required for relatively large footprint device.
- *Retrofit Potential*: Unlined detention basins can be retrofitted.
- *Construction*: Retrofits of existing detention basins will impact operations at the affected facility.

Advantages:

- Combining sedimentation/filtration in a single vault will improve effluent quality while using a smaller footprint as a DB.

Constraints:

- IX resin beads must be kept at a minimum humidity level. It is not clear at this point how this issue should be addressed.
- The clogging rate of the filters is unknown.

Sources:

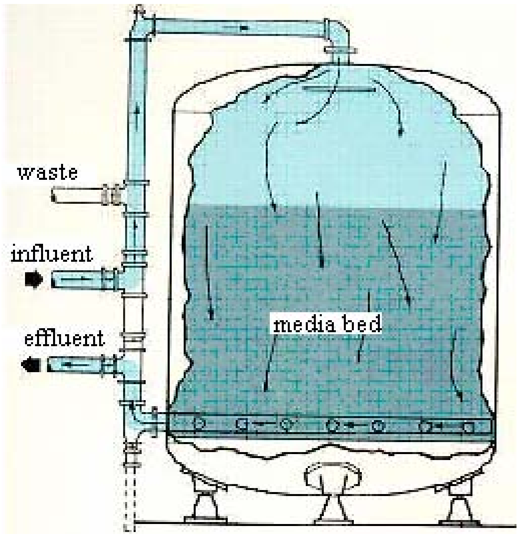
- Aqua-Filter™ Stormwater Filtration System
- Aquashield, Inc. www.aquashieldinc.com

Literature Sources of Performance Demonstrations:

- www.epa.gov/region1/assistance/ceitts/stormwater/techs/aquafiltersys.html

Description:

Media filters purify water primarily by physical filtration of undissolved pollutants as the fluid passes through sand or granular media. Pressure filter systems use pressure provided by an external pump to force water through the filter. Solids collect at the top of the sand media as the storm water passes through the media bed. The treated effluent exits the bottom of the filter and is discharged to a receiving water. Pressure filters also require backwashing, a process that requires water to be forced through the media bed by an external pump. The backwash wastewater containing sediments trapped during filtration can be discharged to a sanitary sewer or a drying bed for disposal. This alternative is a combination of a storage basin, automatic pool vacuum cleaner, basket strainer and pressure filter. Screened storm water fills the empty detention tank; then the automatic cleaner, strainer and filter treat the runoff passes through a coarse screening for litter and trash removal.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	◒	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No demonstration of performance in literature available.

Caltrans SWMP Category:

Category III

Key Design Elements:

1. Filtration rate.
2. Media type and depth.
3. Facilities for containing media and passing water through the filter bed.

<u>Ancillary Facilities</u>

Sedimentation facilities required upstream. Backwash water storage and disposal facilities.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	◒

● High	◒ Medium	○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Residual handling. Mechanical equipment must be maintained.
- *Nuisance Control:* None identified.
- *Traffic Control*: None identified.
- *Staffing/Equipment:* Crews will need to be trained to maintain equipment.

Project Development:

- *Right-of Way-Requirements*: Not Available.
- *Siting Constraints*: Restricted to sites with available nearby power and possibly a sewer connection.
- *Retrofit Potential*: Similar to detention basin. Access is required.
- *Construction*: None identified.

Advantages:

- The use of pressure, rather than gravity, to force water through a media bed allows a smaller footprint. Backwashing cycle reduces maintenance by cleaning sediment from the filter media as opposed to excavating a portion of the media at the end of the season as required for slow sand gravity filters. The pressure filter media will not need to be replaced as often as a gravity filter media, which must have its surface scraped to remove surface deposits. Pressure filter technology uses pumps, which allow more siting flexibility than gravity filtration.

Constraints:

- Connection to sewer or drying bed for backwash waste water is needed. Connection to a potable water supply or backwash water tank for backwashing is needed. Electric power supply for pump is required. Potentially higher capital costs due to pump and pressure tank. More maintenance is needed for a pressure filter than for a gravity filter because of the use of mechanical equipment. Best suited for maintenance stations and park-and-ride facilities in urban settings.

Sources:

- Bachhuber, J. A. Pressurized Filtration System for Treatment of Urban Stormwater Pollution. Earth Tech. Inc. 1999.
- Pressure Filtration. Infilco Degremont, Inc.
- Arkal, Filtration Systems, Arkal Media Filter
- http://www.infilcodegremont.com/
- www.arkal-filters.com/agriculture/arg_meida.html

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Self-backwashing sand filter systems treat water primarily by physically filtering pollutants as water passes upward through the sand media. Solids collide with sand particles and flocculate with other solids as they flow through the media. The filtrate flows up and out of the top of the filter. The sand bed and the accumulated solids, are drawn down into an airlift pipe. The sand and solids are then transported by the airlift from the bottom of the bed to a washer/separator with a central reject compartment at the top of the device. As the sand falls through a washer consisting of several concentric stages, a small amount of the filtered water passes upward, washing away the solids while allowing the heavier, coarser sand to fall to the top of the filter bed. In this way sand is constantly circulated and cleaned. A constant wash/rejection stream of backwash water exits near the top of the filter (potentially returned to EDB). The main components of this package unit are stainless steel tanks, an air control panel and a standard or double bed filtration. For large flow application, a concrete basin design consisting of multiple modules within individual cells can be used.

Constituent Removal:

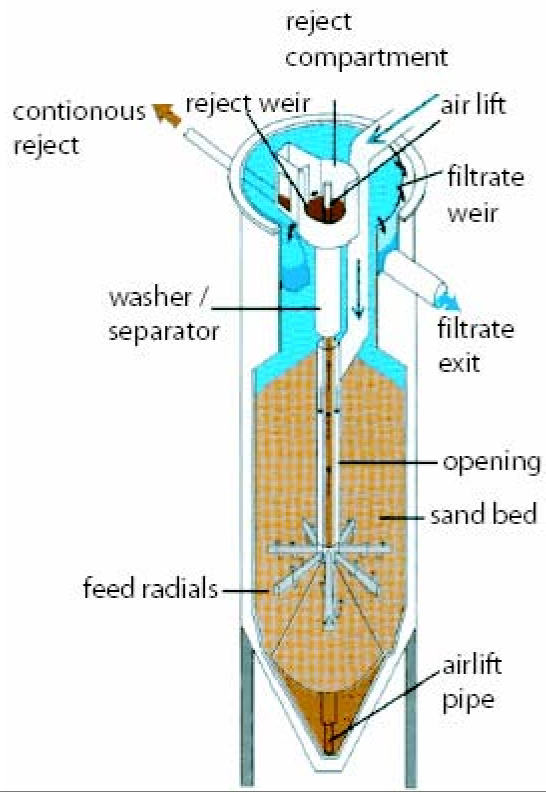
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No demonstration of performance in literature available.

Caltrans SWMP Category:

Category III



Key Design Elements:

1. Effective overflow rate (for sizing the sedimentation chamber).
2. Size and mounting of plates or tubes.
3. Sludge collection and removal facilities.

<u>Ancillary Facilities</u>

Necessarily installed in a sedimentation basin that may or may not precede a filter.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	◳	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Residual handling. Must maintain complex mechanical equipment.
- *Nuisance Control*: Not identified.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment*: Mechanical equipment maintenance. Special training required.

Project Development:

- *Right-of-Way Requirements*: No concerns identified.
- *Siting Constraints*: Restricted to sites with available nearby power and possibly a sewer connection. The system is relatively tall.
- *Retrofit Potential*: Units are compact, but have multiple utility requirements.
- *Construction*: Propriety device.

Advantages:

- The main advantage of the self-backwashing filter over a traditional sand filter is that the bed filter is continuously cleaned. Continuous backwashing allows cleaning of the sediment from the filter without excavating a portion of the media at the end of the season as required for slow sand gravity filters. No shutdowns required for backwashing, and no separate backwash water source or storage is needed. Internal airlift reduces wear and maintenance requirement. Lower electricity consumption than a pressure filter. Use of pressure, rather than gravity, to force water through media bed allows for a smaller footprint. Allows installation of filters where there is insufficient head for gravity filtration.

Constraints:

- The power requirement is the primary operational constraint for the self-backwashing filter. Most suited for maintenance facilities.
- Proprietary technology.
- Height of the unit.
- Requires connection to sewer lateral or drying bed for backwash water waste stream (potentially directed to EDB).

Sources:

- Counterflow Sand Filter, Huber Technologies.
- http://www.huber.de/produktee/cfsfe.htm April 2000.

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Infiltration trenches are typically excavated and backfilled with rock to create a temporary underground storage reservoir for localized storm runoff. Captured flows stored in the trench gradually infiltrate to the surrounding soil substrate. Pollutant removal is achieved primarily through adsorption, straining and microbial decomposition in the surrounding soil. Trenches would capture storm water runoff from the storm drain outfall. Pretreatment of the runoff would be necessary to remove litter, debris and sediments that would rapidly clog the trench. Several detention and infiltration basin technologies are available, including Rainstore3 from Invisible Structures, Inc., High Capacity Infiltrator Chamber from Infiltrator Systems, Inc., and StormChamber from HydroLogic Solutions, Inc. Infiltration trenches have been used successfully in some locations in the United States. However, siting and operational considerations may limit their use as an urban water quality BMP. They include: the need for a soil substrate with relatively high infiltration rates; the high incidence of clogging for this technology, especially when pollutant loads from construction are allowed to enter the facility; the potential threat to local groundwater; and the expense of remediation for a clogged trench.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	●	◒
Microbiological	●	◒
Litter	●	◒
BOD	●	◒
TDS	●	◒

Notes:

- Removal efficiency for infiltration is assumed to be 100% for the design water quality volume since no water is discharged to surface waters.

Caltrans SWMP Category:

Group III

For trench layout see Fact Sheet C-28
Source: www.invisiblestructures.com

Key Design Elements:

1. Sizing based on infiltration rate.

Ancillary Facilities

Pretreatment to remove particles is required to avoid clogging the infiltration surface. This will normally require sedimentation and filtration facilities upstream.

2. Class V injection well determination.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
Construction	▝	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Safety measures are required if the trench is in the ROW.
- *Nuisance Control:* Standing water present in the trench can introduce a breeding ground for mosquitoes and other vectors. Slight odors might be present.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment. Routine maintenance is also required on the infiltration trench to determine whether clogging has occurred.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high depending on the trench desired and pretreatment implemented.
- *Siting Constraints*: Restricted to sites with appropriate soil characteristics and low water table.
- *Retrofit Potential*: Potential where adequate space is available and soil substrata have a high infiltration rate.
- *Construction:* Unexpected soil characteristics or water table location. Possible contamination of groundwater; water percolation may disrupt roadway foundation or fill slope stability.

Advantages:

- These BMPs prevent the design surface runoff from reaching receiving water (i.e., they are “no surface discharge BMPs”).
- They are not limited to a length-to-width ratio and can be fitted along the road in the freeway right-of-way; and layout and design are based on available space and drainage surface area.
- Infiltration trenches offer lesser chance for mosquito breeding and vector propagation. As an underground BMP, trenches have few negative visual aesthetic impacts. They do not require power, making them good candidates for retrofitting in the freeway right-of-way. Few or no mechanical devices would be needed, depending on the pretreatment device selected.

Constraints:

- Vulnerable to clogging, especially when improper construction sequencing or inadequate pretreatment allows high sediment loads to enter the trenches.
- Rehabilitation cost per unit of treated water volume is high. Infiltration trenches require reconstruction every 10 years (U.S. Department of Transportation, 1996). If well designed, they should not require much maintenance between reconstruction.
- Many soil and bedrock types are unsuitable for infiltration basin technologies due to low porosity and permeability, especially in areas with hydrologic soil groups C or D.
- Cannot be placed in areas with locally high water tables. They may cause groundwater contamination if chemicals or fuel are spilled on the highway. They may not be appropriate above sensitive aquifers unless they have an effective, reliable pretreatment system to prevent groundwater contamination. They require proper construction practices to avoid excessive compaction of the substrate.
- Over time, infiltration of polluted storm water may lead to accumulation of dissolved salts and toxics that may harm vegetation and pollute groundwater (Schueler, 1987).
- Significant space is required, mainly because fill rock typically occupies 60 to 65% of the trench volume.

Sources:

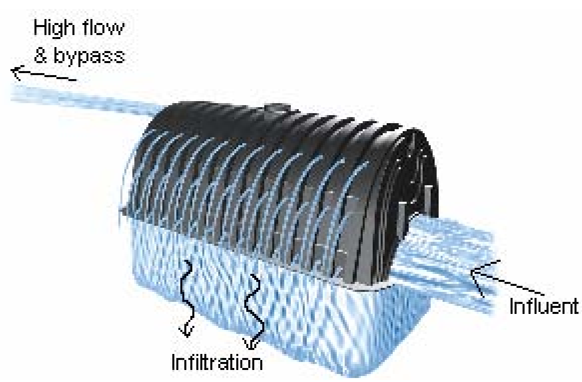
- Rainstore3 Invisible Structures, Inc. http://www.invisiblestructures.com. May 2000.
- Harris, Kathy. Infiltrator Systems, Inc. High Capacity Infiltrator Chamber. http://www.infiltratorsystems.com. June 2000.

Literature Sources of Performance Demonstrations:

- ASCE, Manual and Report on Engineering Practice No. 87. 1998.
- Loomis & Moore, et al. Draft Integrated Solutions Development Study Watersheds Master Plan, Prepared for the City of Austin Watershed Protection Dept. 1998.
- Robert Bein, William Frost and Associates, Scoping Study, Retrofit Pilot Program, Caltrans District 11. February 1998.
- Sansalone, J. J., et al. “Infiltration Device as a Best Management Practice for Immobilizing Heavy Metals in Urban Highway Runoff.”

Description:

The Cultec Contactor™ and Recharger™ plastic leaching systems are examples of subsurface storm water management. Sometimes they replace conventional pipe systems and retention ponds. Design vary according to the manufacturer. The storm water or effluent is then absorbed onto the filter fabric covering and is leached into the surrounding backfill or directly absorbed into the soil or broken syane base.
Infiltration BMPs with below grade storage use a variety of structures to capture storm water and allow it to infiltrate into the surrounding backfill and soil. High flow bypasses can be incorparated for overflow conditions. Cultec chambers provide available open bottom interface.



Source: www.cultec.com

Key Design Elements:

- Distance to groundwater
- Permeability of soils.
- Class V injection well determination

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- Chambers can be placed in either trench or bed configurations by utilizing the patented interlocking rib connection.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*:
- *Nuisance Control:* None identified, if water infiltrates with 72 hours.
- *Traffic Control*: Unknown
- *Staffing/Equipment:* Likely vactor equipment with the ability to clean horizontal lines. Equipment and training needed for confined space entry.

Project Development:

- *Right-of-Way Requirements*: Large area requirements, but area above grade can be used if constructed properly.
- *Siting Constraints*: Permeable soils, adequate separation groundwater
- *Retrofit Potential*: maybe during reconstruction of parking storage areas
- *Construction:* care needed to prevent soil compaction.

Advantages:

- Total drainage interface averages more than 60% higher than conventional PVC pipe and stone system of comparable size.
- Recharger, known for its high performance, quality and cost effective design, manufacturer claims more than 1,000 times the infiltrative capability of large-diameter pipe.

Constraints:

- Must be placed on permeable soil.
- Must avoid high groundwater
- Must avoid areas prone to spills of groundwater contaminents.
- Must addres EPA class V injection well regulations

Sources:

- Cultec, Inc., www.cultec.com
- StormChamber™, HydroLogic Solutions www.hydrologicsolutions.com
- http://www.epa.gov/safewater/uic/pdfs/fact_class5_stormwater.pdf “When Are Storm Water Discharges regulated As Class V Wells?”
- www.invisiblestructures.com/RS3/rainstore.htm

Literature Sources of Performance Demonstrations:

- None identified.

Description:

A breakaway litter bag installed at the storm water outfall is designed to capture litter. When the bag fills up, it is pushed off the pipe and ties off automatically. Can be used as a stand-alone litter removal device or as inlet to an extended detention basin.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- The Breakaway litter bags are not assumed to provide storm water pollutant removal.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness

Caltrans SWMP Category:

Category III

Source: www.nettech.com.au

Key Design Elements:

1. Proprietary device.
2. Bag capacity.

Ancillary Facilities

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Requires access road for maintenance. Frequent inspections may be required to check on the nets.
- *Nuisance Control:* Odors might be of concern without proper maintenance. Standing water may create a breeding ground for mosquitoes or other vectors.
- *Traffic Safety*: During routine maintenance traffic control will be necessary.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Requires access road for maintenance.
- *Siting Constraints:* Little or no site development needed to implement.
- *Retrofit Potential*: This design can be retrofitted to existing storm water outfalls or designed into new installations. The litter bag design can also be adapted to various flow and litter loading rates.
- *Construction:* Patented devices are required but various manufacturers are available.

Advantages:

- Requires minor site work
- Low maintenance cost
- Low construction cost
- Ability to retrofit onto storm water outfalls, pipe culverts and channels of any shape
- Human contact with the litter is minimized or eliminated

Constraints:

- Breakaway litter bags are proprietary patented devices.
- Regular and possibly frequent maintenance/ inspections are required
- Possibility of mosquito breeding and litter decomposition.

Sources:

- http://www.nettech.com.au

Literature Sources of Performance Documentations:

- None identified.

Description:

These litter and debris removal devices are flow-through structures with a settling or separation unit to remove litter, sediments and other pollutants; separation is accomplished using the energy of the water by means of swirl action or indirect filtration. For in-line Vortechs Systems without a bypass, sizing criteria are based on providing one square foot of grit chamber surface area for each 100 gpm of peak design storm flow rate (i.e., 10-year storm). Other examples are listed under “sources.”

Constituent Removal:

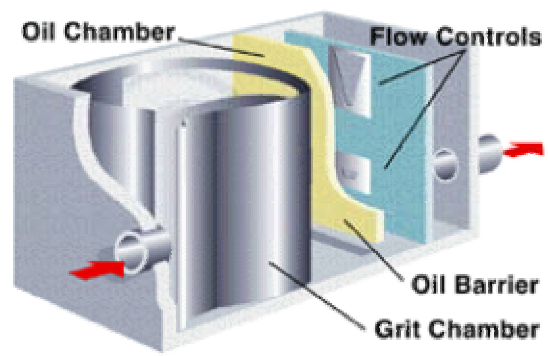
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- No performance data encountered in literature.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness.

Caltrans SWMP Category:

Category III



Vortechs™ Storm Water Treatment System

Key Design Elements:

1. Detention time.
2. Aeration system.
3. Grit removal facilities.

<u>Ancillary Facilities</u>

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Initially the site needs to be monitored 3 or 4 times a year in order to determine accurately the required cleaning frequency.
- *Nuisance Control:* N/A.
- *Traffic Control*: Rarely located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and test for hazardous waste.

Project Development:

- *Right-of-Way Requirements*: May involve relocation of underground utility lines crossing the device. Space requirement is variable.
- *Siting Constraints*: May be used in-line or as a bypass and requires limited space to implement.
- *Retrofit Potential*: Will require a bypass system for high flow rates.
- *Construction*: Need to verify location of existing underground utilities at the site, also may require traffic control during construction

Advantages:

- Small footprint, all underground, and no additional ROW or easement required.

Constraints:

- May require periodic and frequent maintenance.

Sources:

- Vortechnics, Inc.
- http://www.vortechnics.com/vortechs/vorspec.html
- CDS Techbnologies
- http://www.cdstech.com
- Hil Technologies
- Stormceptor, Inc.
- Environment 21 Inc.
- Grande Novac and Associates Inc.

Literature Sources of Performance Demonstrations:

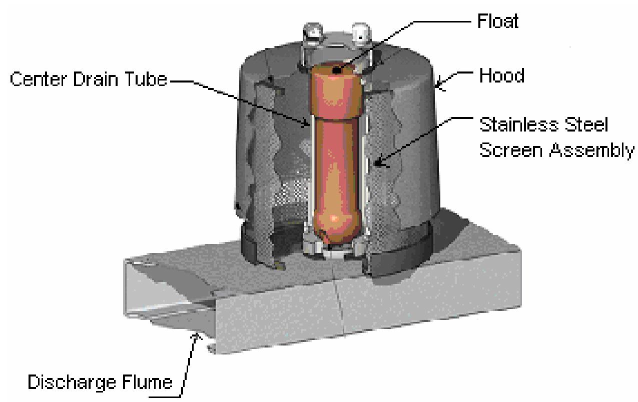
- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/vortechs.html

- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormceptor.html

BMP Fact Sheet
Litter And Debris Removal – StormScreen

Description:

The StormScreen™ is a passive, high-flow screening system used for removal of trash and debris and some TSS from stormwater runoff. The system revolves around the float-actuated, siphonic, radial flow StormScreen cartridge. The stormScreen utilizes a patented self-cleaning mechanism that prevents binding of the screen surface. The cartridge will continue to operate at 225gpm even at 80% or more occusion to the screen surface. This system also incorporates a high flow bypass for peak flow diversion. StormScreen can be installed into small, prefabricated catch basins or incorporated into large, cast-in-place facilities that treat hundreds of cubic feet per second (cfs).



Cylinder installation similar to StormFilter
(see StormFilter C-38)

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- StormWater™'s Drain-Down™ system can be incorporated with StormScreen.
- StormScreen and StormFilter systems can be used in combination for larger sites with a high flow rate or volume that need to be treated or a large amount of trash and debris that needs to be captured.

Key Design Elements:

StormScreen™ is sized to treat the peak flow from the design storm. The peak flow is determined based on the watershed area and design storm magnitude. StormScreen™ canisters are designed to treat 0.5 cfs (225gpm) each.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Maintenance expected to be similar to the other litter and debris removal BMP's.
- *Nuisance Control:* None identified.
- *Traffic Control*: Unlikely, if properly located away from traveled way.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Requires access for maintaince.
- *Siting Constraints*: Minimum system head loss of 0.6096m, (2ft).
- *Retrofit Potential*: It can be applied in confined urban areas and areas with limited space since it is an underground vault.
- *Construction:* Modular units available.

Advantages:

- Multiple stainless steel screens; protective hood covers; siphon-actuated self cleaning mechanism; minimal excavation depth; optional dewatering system for reducing BOD, vector incubation, etc.; easily replaced screens.

Constraints:

- Although the screen is able to remove particles greater than the pore size (2.4mm) the system relies on finer sediments attaching to larger sediment for removal. Recommended use for gross pollutant removal, absorbents may need to accompany for additional petroleum hydrocarbon removal.

Sources:

- Will Haris, Senior Regional Manager, StormWater Management INC.
- www.stormwaterinc.com

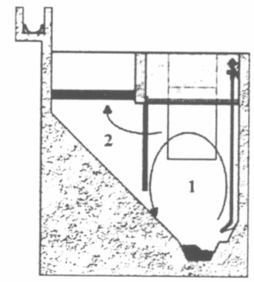
Literature Sources of Performance Demonstrations:

- None identified.

BMP Fact Sheet
Sedimentation-
Grit/Water Separators

Description:

Air is introduced into a grit chamber by bubble diffusers in a "roll pattern," causing the grit to settle to the bottom. The settled grit particles are then removed via a grit pump through a traveling bridge type mechanical removal system. The channel basin is sized to yield approximately a 5-minute detention time, with a length-to-width ratio of approximately 10:1. The grease is removed in an adjacent vault by air flotation.



1. Grit Removal Section by hydraulic roll
2. Grease Removal Section by air flotation

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No known stormwater applications.
- No performance data encountered in field demonstrations or in literature.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness.

Key Design Elements:

1. Detention time.
2. Aeration system.
3. Grit removal facilities.
4. Power requirements

Caltrans SWMP Category:

Category III

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▗	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Grit removal and disposal that requires mechanical equipment.
- *Nuisance Control:* Unknown
- *Traffic Control*: Unknown
- *Staffing/Equipment:* Supervision by operator.

Project Development:

- *Right of Way Requirements*: Space requirements for the grit chamber are relatively low compared to EDB. May involve relocation of underground utility lines crossing the device.
- *Siting Constraints*: Power source must be available.
- *Retrofit Potential*: Will require a bypass system for increased flow rates.
- *Construction***:** Need to verify location of existing underground utilities at the site.

Advantages:

- Removes litter, grit, and suspended solids very efficiently.

Constraints:

- Requires electricity to operate and needs regular monitoring.
- Requires supervision

Sources:

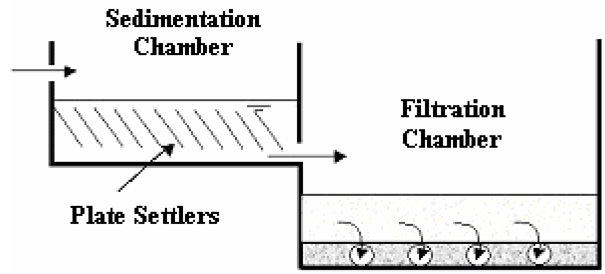
- Schreiber Corporation, Degremont S.A.
- http://www.schreiberwater.com
- http://www.infilcodegremont.com/densadeg.htm

Literature Sources of Performance Demonstrations:

- No information encountered.

Description:

Improving sedimentation in the first chamber of an Austin filter or in a concrete detention basin can be achieved by installing plate or tube settlers in this chamber. Sedimentation of aqueous suspensions is accelerated by decreasing the distance particles must fall prior to removal. This can be achieved by making the basin shallower, but this is limited by practical aspects. One approach is to provide parallel plates or inclined tubes that permit solids to reach the bottom after only short distances of settling.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- Removal efficiencies assumed plate and tube settlers used in conjunction with an EDB.
- No performance data encountered in field demonstrations.
- The tube or plate settlers will enhance the sedimentation of fine particles.
- The Multi-Chambered Treatment Train (MCTT) developed by the University of Alabama-Birmingham includes a sedimentation chamber with tube settlers.

Key Design Elements:

1. Effective overflow rate (for sizing the sedimentation chamber).
2. Size and mounting of plates or tubes.
3. Sludge collection and removal facilities.

Ancillary Facilities

Necessary installed in a sedimentation basin that may or may not precede a filter.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Cleaning and maintenance of the plate or tube settlers may require removing the plate settler structure. Litter may get trapped in the tube settler structure.
- *Nuisance Control:* Same as Austin filter.
- *Traffic Control*: Rarely located along a shoulder or median.
- *Staffing/Equipment:* Information not available.

Project Development:

- *Right-of-Way Requirements*: Same as Austin filter.
- *Siting Constraints*: Most suitable for maintenance stations and park-and-ride lots.
- *Retrofit Potential*: Can be installed in existing Austin sand filter.
- *Construction:* Information not available.

Advantages:

- Same as Austin Filter.

Constraints:

- Susceptible to clogging.
- Maintenance is more difficult than an open basin.

Sources:

- None.

Literature Sources of Performance Demonstrations:

- Harper, H. H., et al. "Performance Evaluation of Dry Detention Stormwater Management Systems." Sixth Biennial Stormwater Research Watershed Management Conference. September 1999.
- High-Rate Sedimentation, WWF Plan Project Number 4.19. EPA Urban Watershed Management Branch. http://www.epa.gov/ednnrmrl/projects/control/high.htm. April 2000.
- Keblin, Michael, et al. Effectiveness of Permanent Highway Runoff Controls: Sedimentation/Filtration Systems. October 1997.
- Meinholtz, T. L., et al. Screening/Floatation Treatment of Combined Sewer Outflows, Volume II: Full-Scale Operation Racine, Wisconsin. EPA-600/2-79-106a. Aug 1979.
- Pitt, R., et al. Stormwater Treatment at Critical Areas, Vol. 1: The Multi-Chambered Treatment Train. Cincinnati: US EPA. 1997.
- Robert Bein, William Frost and Associates, Scoping Study, Retrofit Pilot Program, Caltrans District 11. February 1998.
- James M. Montgomery Consulting Engineers, Inc, Water Treatment Principles and Design. 1985.
- United States Department of Transportation, Federal Highway Administration, Office of Environmental Planning: Evaluation and Management of Highway Runoff Water Quality, Washington, DC. June 1996.

Description:

The StormTreat™ System (STS) consists of a series of sedimentation chambers and constructed wetlands. These wetlands are contained within a modular, 2.9-meter (9.5) ft diameter recycled-polyethylene tank that is roughly four feet in height. Unlike most constructed wetlands systems, STS conveys the storm water directly into the subsurface of the wetland and through the root zone. Pollutants are then removed through filtration, adsorption, and biochemical reactions. Storm water is retained in the wetlands for five to ten days prior to discharge.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	◒
Nutrients	●	◒
Pesticides	●	◒
Total Metals	●	◒
Dissolved Metals	○	○
Microbiological	●	◒
Litter	○	○
BOD	◒	◒
TDS	◒	○

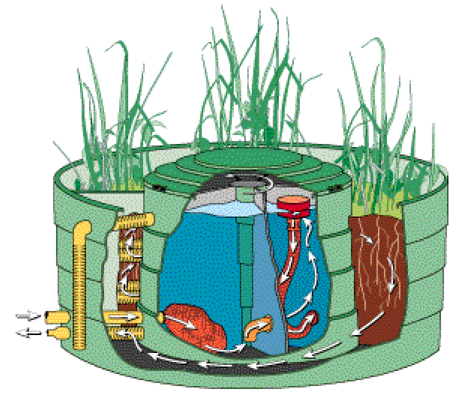
Notes:

- Data collected over a two-year period by clients, analyzed by state-certified labs and verified by the Commonwealth of Massachusetts.
- Thirty-three samples were collected over eight independent storm events during both winter and summer conditions.

Caltrans SWMP Category:

Category III

Key Design Elements:



1. Modular, 2.9-meter (9.5-foot) diameter recycled-polyethylene tank containing a series of sedimentation chambers and constructed wetlands.
2. Flow is conveyed from the final sedimentation chamber through four, slotted PVC outlet pipes, each 10-cm (4 inches) in diameter, into the wetland.
3. Mature vegetation in the outer ring should have roots that extend into the permanent 15-cm (6 inches) of water in the bottom of the tank.
4. Effluent from the wetland is discharged through a 5-cm (2-inch) diameter pipe that is controlled by a valve.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	◳	◒

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Annual inspections and replacement of grit filter bag and sediment pumping once every three to five years using standard septic system pumper.
- *Nuisance Control:* None identified.
- *Traffic Control*: Unlikely.
- *Staffing/Equipment:* For routine maintenance, requires staff to remove grit filter bag and septic haulers to pump sediment from the tank.

Project Development:

- *Right-of-Way Requirements*: Moderate
- *Siting Constraints*: The systems size and modular configuration make it adaptable to a wide range of site constraints and watershed sizes. The system can be used to treat runoff from highways, parking lots, airports, marinas, and commercial, industrial, and residential areas. The STS system is not designed to be used directly in wastewater streams.
- *Retrofit Potential*: Generally 1-2 units are required for each acre of impervious surface.
- *Construction***:**

Advantages:

- Protects groundwater by removing pollutants prior to infiltration.
- The spill contamination feature can capture an upstream release and lessen the spill impact on the environment.

Constraints:

- Is a relatively new BMP and remains to be thoroughly tested in different geographical locations.

Sources:

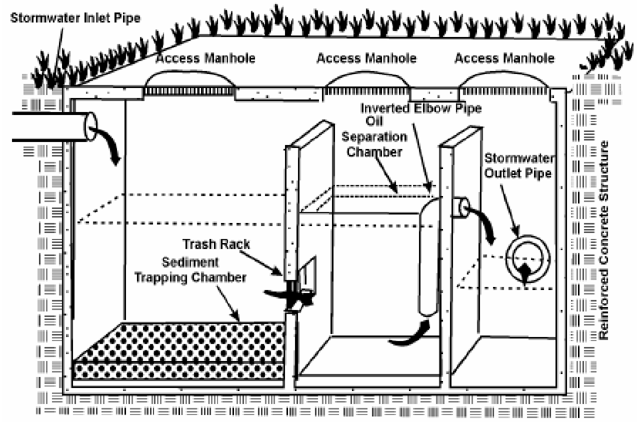
- United States Environmental Protection Agency.
- StormTreat™ Systems, Inc., 1998

Literature Sources of Performance Demonstrations:

- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormtreat.html

Description:

"Water quality inlets (WQIs), also commonly called oil/grit separators, consist of a series of chambers the promote sedimentation of coarse materials and separation of free oil from storm water. Most WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalexcing unit that helps to promote oil/water separation. WQIs typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other best management practices (BMPs)." (source:EPA Storm Water Technology Fact Sheet, "Water Quality Inlets")



Profile of a typical Water Quality Inlet

(source: Berg, 1991)

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- WQIs can be purchased as pre-manufactured units or constructed on site.
- Suppliers of pre-manufactured units can also provide modifications of the typical design for special conditions.

Key Design Elements:

1. Peak Flow
2. Offline vs. Online
3. Water quality design flow
4. Residence time (BMP sizing vs. Water quality flow rate)

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	▗	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: The WQIs are designed to retain captured pollution over multiple rain events. WQIs should be inspected, floatables should be removed, and the sediment removed when the units are 50% to 85% full.
- *Nuisance Control:* Vector inspections are required since many units hold a permanent pool of water.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove floatables and debris. Vactor truck is the most common method of cleaning.

Project Development:

- *Right-of-Way Requirements*: Depending on the size and configuration of the equipment required for BMP construction, adequate space may not be available.
- *Siting Constraints*: WQIs should be sited where there is adequate access for maintenance of the facility. A vactor truck is the normal maintenance method.
- *Design Complexity*: Proprietary devices.
- *Retrofit Potential*: Relatively smaller size increase retrofit potential.
- *Construction*: BMP sites within freeway right-of-way are often located in areas with limited available lay-down space. Depending on the size and configuration of the equipment required for BMP construction, adequate space may not be available.

Advantages:

- WQIs can trap trash, debris, oil and grease, and other floatables.
- WQIs are typically smaller than basin type BMPs.

Constraints:

- WQIs have limited ability to separate dissolved or emulsified oil from runoff.
- WQIs are also not very effective at removing pollutants such as nutrients or metals.
- Standing water may create mosquito habitat.

Sources:

- Aqua-filter™ Stormwater Filtration System
- Aquashield, Inc. www.aquashieldinc.com
- Baysaver®, Inc., 1998. *Baysaver® Separation System Technical and Design Manual*. www.baysaver.com
- Downstream Defender™
- EcoStorm, Royal Enviromental Systems, Inc. www.royalenterprises.net
- SNOUT Oil-Debris Separator
- Stormceptor™
- Storm Water Technology Fact Sheet Water Quality Inlets www.epa.gov/owm/mtb/wtrqlty.pdf
- Stormwater™ Management Inc.
  - -Stormgate™
  - -Stormgate Seperator™
  - -Stormfilter™
  - -Catchbasin Stormfilter™
- Vortechnics™ http://www.vortechnics.com
- V2B1™ Stormwater Treatment System

Literature Sources of Performance Demonstrations:

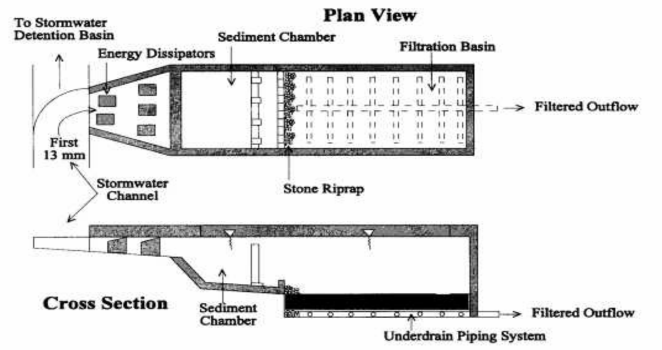
- www.epa.gov/region1/assistance/ceitts/stormwater/techs/aquafiltersys.html
- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/downstreamdefender.html
- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/baysaver.html
- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormceptor.html
- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/snout.html
- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/stormfilter.html
- http://www.epa.gov/region1/assistance/ceitts/stormwater/techs/v2b1.html

APPENDIX C: PILOT FACT SHEETS

Appendix C presents fact sheets for the full-scale BMPs listed in Section 2.2, Table 2-1 that are currently undergoing pilot testing, but are not yet approved by the Department. Technology evaluations in the attached fact sheets are ongoing, and the assessment of these technologies may be revised in future reports. The evaluations that appear were derived from a review of information that was frequently limited to manufacturer's claims. Unapproved treatment BMP technologies under full-scale pilot testing are presented in the following order:

Description:

The Austin sand filter includes a sedimentation basin and a sand media filter. The sedimentation basin captures and detains the design water quality runoff volume (typically for 24 hrs.) prior to discharge to the filter chamber. The sedimentation basin removes floatable debris and coarse suspended solids and prevents premature clogging of the filter media surface. Sedimentation chamber effluent discharges to the sand filtration basin typically through a perforated riser. In the sand filter, the water passes through an 18” sand layer, a geotextile layer, and 6” of gravel. Pollutant removal is achieved primarily by physical filtration of pollutants through the filtration media and settling of solids in the sedimentation basin.



Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	●	●
Nutrients	○	●
Pesticides	○	●
Total Metals	◒	●
Dissolved Metals	○	●
Microbiological	●	●
Litter	●	●
BOD	○	●
TDS	○	●

Notes:

- Nitrate concentrations increase by 35%.
- Filters are self-contained devices that can function on an intermittent basis.
- Data obtained from Caltrans Retrofit Pilot Program. Five Austin sand filters were constructed and monitored.

Key Design Parameters:

1. Design volume for the sedimentation basin should be increased to account for reduction in storage volume due to deposition of solids.
2. Orifice plate on the outlet riser should be sized so that the sedimentation basin drains from a full basin condition in 24 hours.
3. The underdrain piping should consist of a main collector pipe and two or more lateral branch pipes with a minimum slope of 1%.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	▝	●

Five Austin sand filters were constructed for retrofit and monitored. An average of 45 field hours/year were spent on O&M for each sand filter. Caltrans Cost Summary report CTSW-RT-01-003

Caltrans SWMP Category:

Category III

● High ◒ Medium ○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: A maintenance ramp should be incorporated to allow equipment into the sedimentation basin and filter basin for routine cleaning sediment and debris.
- *Nuisance Control:* The spreader ditch in the filtration chamber holds water and can provide breeding habitat for mosquitoes. The spreader ditch may be omitted from the traditional design if another energy dissipation method is provided in front of the riser outlet to the filter bed.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for sedimentation basin and sand filter.
- *Siting Constraints*: Should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. Excessive amounts of sediment will cause premature clogging of the filter.
- *Design Complexity*: Sand filters should be sited where enough vertical clearance (head) is provided, about 1.5 meters. Detailed geotechnical investigation prior to construction is recommended.
- *Retrofit Potential*: Retrofit of sand filters at maintenance stations and park-and-ride lots impacts the operation of the facility during construction.
- *Construction*: Sand specified should be a standard locally available well-washed sand mix that generally meets the design requirements for permeability. Excavation problems may be magnified due to the large, deep design of the sedimentation basin and sand filter, the need to intercept existing storm drains, and the desire to minimize footprint area. Field conditions such as structurally unsuitable soils, buried manmade objects and existing utility lines may be encountered.

Advantages:

- The Austin sand filters have good constituent removal for suspended solids, total metals, and bacteria. They can provide consistent pollutant removal when properly maintained.
- They can treat runoff from drainage areas up to 20 hectares.
- They can reduce the potential for groundwater contamination if they are designed with an impermeable basin liner.
- They can be added to retrofit highly developed existing sites.

Constraints:

- Sand filters can be relatively expensive to construct and maintain.
- Limited pollutant removal for nutrients.
- If sufficient head is not available, the use of pumps may be required, which result in higher costs and more frequent maintenance.

Sources:

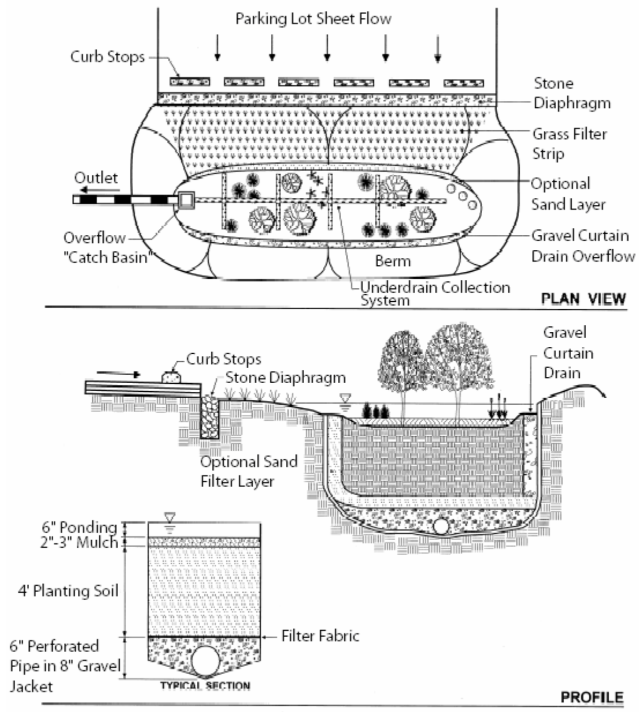
- M. Barrett, University of Texas at Austin
- http://www.epa.gov/owm/mtb/sandfltr.pdf
- http://enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- http://webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- The US Department of Transportation "Evaluation and Management of Highway Runoff Water Quality" Young et al. 1996 – contains info. on siting, design, and performance.
- Glick, Roger Chang, George C., and Barrett, Michael E., Monitoring and evaluation of stormwater quality control basins, in Watershed Management: Moving from Theory to Implementation, Denver, CO, May 3-6, 1998, pp. 369-376.

Description:

Bioretention facilities are designed to capture and retain the storm water quality volume in a shallow, offline, vegetated retention area. They are typically used to treat small (0.25 to 1.0 acre), highly impervious surfaces such as park-and-ride facilities and maintenance yards. Bioretention facilities are intended to promote infiltration, evaporation and evapotranspiration of the water quality volume. Bioretention basins are smaller and less obtrusive than infiltration basins. Bioretention basins may have an underdrain connected to the storm drain if native soils are not sufficiently permeable. Careful landscaping and planting can provide a positive aesthetic appeal. Runoff should enter the facility in a sheet-flow manner across a grassed buffer to minimize introduction of sediment into the retention basin. Maximum ponding depths should be chosen in conjunction with measured infiltration/transportation rates to ensure that the facility will be dry within 72 hours to prevent mosquito propagation. The footprint is about 10 percent of the contributory drainage area (depending on required capture volume). Biorentention is well-suited for use around maintenance stations and park-and-ride facilities where a vegetated buffer area may provide screening and an aesthetic element is desirable to adjacent property owners. It may also prove to be appropriate for highway rest areas or rural areas.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	◒	○
Pesticides	◒	○
Total Metals	●	○
Dissolved Metals	○	○
Microbiological	●	○
Litter	●	○
BOD	●	○
TDS	○	○

Notes:

- No performance data encountered in field demonstrations or in literature.

Caltrans SWMP Category:

Category III

Key Design Elements:

1. Size (based on infiltration rate).
2. Vegetation.
3. Underground drain system if groundwater pollution is a concern.
4. Ponding depth.
5. Surface area
6. Depth and type of soil
7. Planting plan

<u>Ancillary Facilities</u>

None.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	○

● High ◒ Medium ○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- Requirements: Regular vegetation management is required.
- Nuisance Control: The bioretention facility can promote mosquito breeding and sheltering of endangered species.
- Traffic Control: No concerns identified.
- Staffing/Equipment: For routine maintenance, staff is required to conduct regular vegetation management to advance the bioretention process.

Project Development:

- Right-of-Way Requirements: Space requirements are relatively high to accommodate shallow water quality storage depths.
- Siting Constraints: Restricted to large sites with appropriate soil characteristics and low water table. Bioretention facilities are limited to sites with adequate adjacent undeveloped land.
- Retrofit Potential: Feasible if right-of-way is available for facility.
- Construction: Vegetation establishment period is required.

Advantages:

- Pollutant removal effectiveness is typically high, accomplished primarily by sedimentation in the primary storage facility; physical filtration of particulates through the soil profile; and dissolved constituents uptake in the vegetative root zone by the soil-resident microbial community. It can provide a highly aesthetic vegetated appearance while providing multi-purpose benefits such as water quality protection.

Constraints:

- May not be appropriate along highways where safety considerations preclude use of large trees or plantings that obscure sight lines. In areas with prolonged dry periods, maintenance of trees, shrubs and grass between rainfalls may require irrigation. Bioretention is limited to sites with adequate adjacent undeveloped land because it requires a large footprint to accommodate shallow water quality storage depths. As with any infiltration facility, clogging can cause water ponding and associated nuisance and vector problems. Use of planting soil to fill the basin may increase costs compared to infiltration basins. It takes time for bioretention facilities to become established while vegetation develops
- Current designs are functional only during dry weather.
- Possible contamination of groundwater can be associated with the bioretention facility.

Sources:

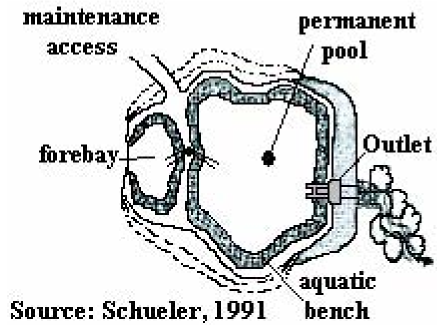
- Loomis & Moore et al 1998. Draft Integrated Solutions Development Study Watersheds Master Plan, Prepared for the City of Austin Watershed Protection Dept.
- Maryland Dept of the Environment and Center for Watershed Protection 2000. Maryland Storm water Design Manual, Volumes I & II.
- Schueler, T. R. et al. Draft Maryland Storm water Design Manual, Maryland Department of the Environment in Cooperation with the Maryland Department of Natural Resources Coastal Zone Management Program. 1998.
- CWP, 1996. Design of Stormwater Filtering Systems Center for Watershed Protection. December 1996

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Constructed wetlands attempt to replicate some of the conditions in natural wetlands. Constructed wetlands for stormwater treatment typically are shallow (less than 2 meters) ponds with a variety of wetland plant species. The ponds often incorporate forebays to localize sediment accumulation, shallow zones to encourage filtration by plant material, and deeper zones to allow further sedimentation. The water quality benefits of treatment in natural or constructed wetlands include nutrient cycling and removal, and reduction in suspended solids (TSS), total dissolved solids (TDS), trace metals, and BOD.



Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	◒	◒
Nutrients	◒	◒
Pesticides	○	○
Total Metals	◒	◒
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	◒
BOD	◒	◒
TDS	◒	◒

Notes:

- None identified

Caltrans SWMP Category:

Category III

Key Design Elements:

1. Sediment forebays are recommended to decrease the velocity and sediment loading to the wetland. The forebay should contain at least 10 percent of the wetlands treatment volume and should be 4 to 6 feet deep.
2. The wetland design should include a buffer to separate the wetland from surrounding land.
3. Above ground berms or high marsh wedges should be placed at 50 foot intervals.
4. A four-to-six foot deep micropool should be included in the design to prevent the outlet from clogging.
5. Site must have adequate water flow and appropriate underlying soils.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	◳	◒

● High ◒ Medium ○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Active management of the hydrology and vegetation during the first few years or growing seasons is necessary.
- *Nuisance Control:* The constructed wetland facility can promote mosquito breeding and sheltering of endangered species.
- *Traffic Control*: No concerns identified
- *Staffing/Equipment:* For routine maintenance, staff if required to conduct regular vegetation management and inspections for sediment accumulation and removal, if necessary.

Project Development:

- *Right-of-Way Requirements*: Moderate
- *Siting Constraints*: The system's size and modular configuration make it adaptable to a wide range of site conditions and watershed sizes. The system can be used to treat runoff from highways, parking lots, airports, marinas, and commercial, industrial, and residential areas.
- *Retrofit Potential*: Generally 1-2 units are required for each acre of impervious surface.

Advantages:

- Improvements in downstream water quality
- Settlement of particulate pollutants
- Reduction of oxygen-demanding substances and bacteria from urban runoff
- Enhancement of vegetation diversity and wildlife habitat in urban areas

Constraints:

- May be difficult to maintain vegetation under a variety of flow conditions
- Relatively high construction costs in comparison to other BMP's

Sources:

- None identified

Literature Sources of Performance Demonstrations:

- Schueler, T.R., "Design of Stormwater Pond Systems". Metropolitan Washington Council of Governments, Washington, DC.
- Schueler T. et al., 1992. "A Current Assessment of Urban Best Management Practices.
- Techniques for Reducing Non-Point Source Pollution in the Coastal Zone". 126pp.
- Schueler, T.R., F.J. Galli, L. Herson, P. Kumble and D.Shepp, 1991. "Developing Effective BMP Systems for Urban Watersheds". Urban Non-Point Workshops, New Orleans, Louisiana. January 27-29, 1991.
- Schueler, Thomas R., 1987. "Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's. July.
- Strecker, E.W; J.M. Kersnar; and E.D. Driscoll, 1992. "The Use of Wetlands for Controlling Stormwater Pollution; Final Report", Prepared for Region 5 Water Division, Wetlands and Watershed Section, Watershed Management Unit, USEPA, Chicago, IL. Prepared by Woodward Clyde Consultants, Portland OR. 66 pp.plus appendix.
- Washington State Department of Ecology, 2000. "Stormwater Management Manual for Western Washington, Volume V, Runoff Treatment BMP's. 251 pp. August.
- Kadlec and Knight, 1996, "Treatment Wetlands", Lewis Publishers, NY, NY.

Description:

Continuous Deflective Separation (CDS™) units are placed downstream of drain inlets to capture sediment, trash, and debris (gross pollutants). The units create a vortex of water that allows the water to escape through a screen while contaminants are contained in the unit sump. The vortex action of the water tends to keep the screen clear from trash and debris. A storm by-pass weir is incorporated to allow excess flows to bypass the system, rather than entering the CDS™ unit. This is to prevent the unit from flooding or losing its captured material.

Constituent Removal:

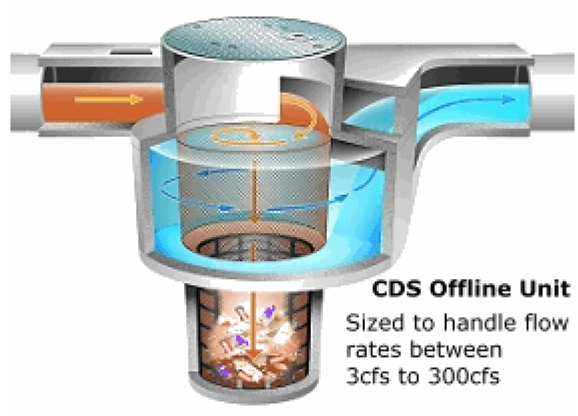
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	○	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	○
BOD	○	○
TDS	○	○

Notes:

- No information on chemistry data is available from the Caltrans BMP retrofit pilot program. Manufacturer reports 2400 micron screen can remove:
  - 100% of particles 425 um or greater
  - 96 % of particles 300-425 um
  - 76 % of particles 150-300 um
  - 42 % of particles 75-150 um
- 4700 micron screen can remove:
  - 100% of particles 2,350 um or greater
  - 93 % of particles 1,551-2,350 um
  - 50 % of particles 940-1,551um
- Two CDS™ units are currently being tested as part of the Caltrans BMP retrofit pilot program. Performance evaluation is currently not available.
- There have been about 160 installations of CDS units in Australia and the Untied States.
- Five studies have been performed on CDS™ units. These studies focused on characteristics of litter and sediments rather than efficiency.

Caltrans SWMP Category:

Category III



Key Design Parameters:

Storm water units that will treat a 1 to 300 CFS flow range. Contact manufacturer for customization of units to meet site specific needs for flow capacities and sump sizes. Flow must be subcritical entering the unit. Sites with continuous dry weather flow are not recommended.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▖	●

Information from Caltrans Cost Summary report CTSW-RT-01-003. Manufacturer can supply cost data for unit only. An average of 63 field hours per year were spent on operation and maintenance of each CDS™ during the Caltrans BMP retrofit pilot program.

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: The CDS™ units are designed to retain captured pollution over multiple rain events. The CDS™ unit should be inspected, floatables should be removed, and the sump cleaned when the sump is above 85% full. There are three methods for cleaning out a CDS™ unit - vactor truck, removable basket, and underflow pump.
- *Nuisance Control:* Vector inspections are required since the unit holds a permanent pool of water.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove floatables and debris.

Project Development:

- *Right-of-Way Requirements*: Depending on the size and configuration of the equipment required for BMP construction, adequate space may not be available.
- *Siting Constraints*: CDS™ units should be sited where there is adequate access for maintenance of the facility. A vactor truck is the normal maintenance method.
- *Design Complexity*: Proprietary device.
- *Retrofit Potential*: Two retrofits accomplished in Caltrans pilot study.
- *Construction*: BMP sites within freeway right-of-way are often located in areas with limited available lay-down space. Depending on the size and configuration of the equipment required for BMP construction, adequate space may not be available.

Advantages:

- Storm water can be treated at the end of pipe, and therefore storm water treatment devices are not needed at each storm drain inlet. The unit is non-mechanical, non-electrical, reducing maintenance issues related to mechanical and electrical devices. Relatively limited head is needed to operate the device (0.5 ft).

Constraints:

- Unit is developed for the removal of gross pollutants only.
- Permanent pool of water is maintained, creating a breeding opportunity for mosquitoes.

Sources:

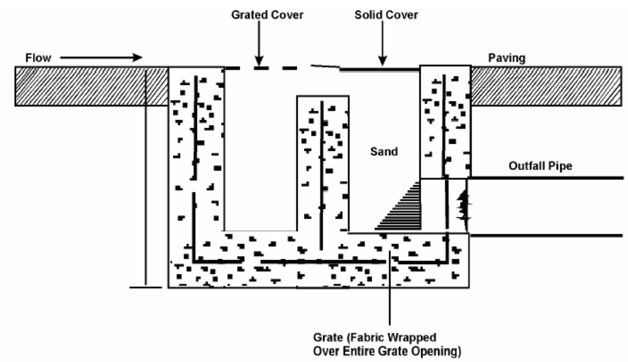
- US Head Office - West Coast
  CDS Technologies
  16360 South Monterey Road, Suite 250
  Morgan Hill, CA 95037
  Toll Free: 888 535 7559
  Phone: 408 779 6363
  Fax: 408 782 0721
  email: cds@cdstech.com
- http://www.CDStech.com.au/articles/StenstromReport.pdf
- http://www.CDStech.com.au/articles/Coarse&Medium-FineSedimentRemoval.pdf
- http://www.stormwater-resources.com/Library/065BCDSFinal.pdf

Literature Sources of Performance Demonstrations:

- None identified.

Description:

Delaware sand filters are often located at the curbside edge of a paved area or parking lot and include two parallel concrete chambers, a sedimentation chamber, and a sand media filter chamber. The sedimentation chamber holds a permanent pool of water. The sedimentation basin removes the coarse suspended solids and prevents premature clogging of the filter media surface. The sedimentation effluent discharges over a weir into the sand filter chamber where water is filtered through a 12- to 18-inch sand filter, geotextile layer, and 6 inches of gravel. Delaware sand filters are on-line facilities; they process all runoff leaving the site up to the point where the overflow limit is reached.
Delaware sand filters can be applied to confined urban areas and areas where space is limited. Parking lots are a common application for the Delaware sand filters.



Source: Shaver, 1991

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	○	●
Pesticides	○	●
Total Metals	●	●
Dissolved Metals	○	●
Microbiological	●	●
Litter	●	●
BOD	○	○
TDS	○	○

Notes:

- Nitrate concentrations increase by 78%.
- High dissolved Zn removal efficiency.
- A Delaware sand filter was sited as part of the Caltrans BMP Retrofit Pilot Program. Although Delaware sand filters are not thought to be effective for removing dissolved constituent, some removal was observed.

Caltrans SWMP Category:

- Category III

Key Design Parameters:

The Delaware unit should be designed and installed according to the guidelines described by Young et al. (1996). It should be noted that if a Delaware filter is designed according to these guidelines, there is only storage in the unit for 5 mm of runoff (0.2 inches); consequently, if it is desired to treat a larger water quality volume, the unit must act as a flow-through device. The filter is sized using unit values for the sedimentation chamber volume and filter bed area per acre of tributary area treated.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		●

Information from Caltrans Cost Summary report CTSW-RT-01-003. An average of 20 field hours per year were spent on operation and maintenance of the Delaware sand filter during the Caltrans BMP retrofit pilot program.

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Maintenance for smaller, underground filters is usually best done manually. Normal maintenance requirements include disposal of accumulated trash and replacement of the upper few inches of dirty sand when the filter drain time exceeds that stipulated in design.
- *Nuisance Control:* The spreader ditch in the filtration chamber holds water and can provide a breeding site for mosquitoes. The spreader ditch may be omitted from the traditional design if another energy dissipation method is provided in front of the riser outlet to the filter bed.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for sedimentation basin and sand filter.
- *Siting Constraints*: Delaware sand filters should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. Excessive amounts of sediment will cause premature clogging of the filter.
- *Design Complexity*: Sand filters should be sited where enough vertical clearance (head) is provided, about 1.5 meters. Detailed geotechnical investigation prior to construction is recommended.
- *Retrofit Potential*: Retrofit of sand filters at maintenance stations and park-and-ride lots impacts the operation of the facility during construction.
- *Construction**:*** Sand specified should be a standard locally available sand mix that generally meets the design requirements for permeability. Field conditions, such as structurally unsuitable soils, buried manmade objects, and existing utility lines may be encountered.

Advantages:

- Delaware sand filters can be installed underground in urban settings and be kept out of sight, or open for large drainage areas. They are similar in performance to the Austin design with the principal advantage being the preservation of the surface use.
- Waste media from the filters does not appear to be toxic and is likely to be environmentally safe for landfill disposal.
- The filters can reduce the potential for groundwater contamination if they are designed with an impermeable basin liner.

Constraints:

- Delaware sand filters are relatively expensive to construct.
- Sand filters have only limited pollutant removal capability for nutrients.
- The sedimentation basin holds a permanent pool of water and has the potential to provide breeding opportunities for mosquitoes.

Sources:

- The Web site, http://www.epa.gov/owm/mtb/sandfltr.pdf has information on design, performance, operation, maintenance, and costs of sand filters.
- Other Web sites with information on performance include:
- http://enviro.nfesc.navy.mil/p2library/
- cgi-bin/p2h_datasheet.cfm?itemID=230
- http://webcentral.bts.gov/ntl/DOCS/RUNOFF.html

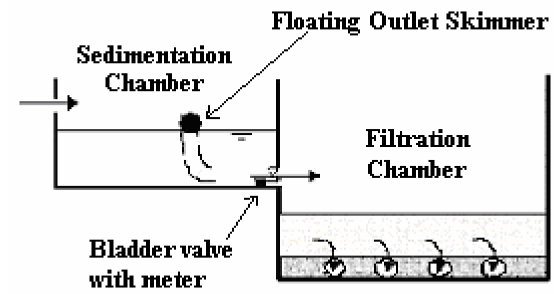
Literature Sources of Performance Demonstrations:

- The US Department of Transportation "Evaluation and Management of Highway Runoff Water Quality" Young et al. 1996 contains information on the siting, design, and performance of Delaware sand filters.

BMP Fact Sheet
Detention Basin, Outlet Improvements – Skimmer or Bladder

Description:

The Improved Extended Detention Basin (EDB) Outlet drains water from the top of the basin to improve the sedimentation efficiency by assuring that settled particles are not accidentally sucked into the discharge. The sedimentation process could be improved by adding an outflow device composed of a skimmer, drainage hose and float to the current BMP design of the Austin Filter for the EDB outlet or to the outlet of a stand-alone EDB. Alternatively, a valve with an inflated bladder can be used to increase detention time. The pneumatic bladder located in the sedimentation chamber outlet drain is inflated when sensors detect rain to provide a set sedimentation time. The tank will be drained or “decanted” from the surface in order to allow more time for the sedimentation process. With the improved sedimentation process, less sediment will be collected on the media filter, reducing maintenance and extending the life of the sand filter.



Key Design Elements:

1. Hydraulic capacity.
2. Means of removing water when skimmer is at its lowest position.
3. Power and controls system for operating outlet bladder or valve.

<u>Ancillary Facilities</u>
Extended detention basin.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	○
Nutrients	○	○
Pesticides	◒	○
Total Metals	◒	○
Dissolved Metals	○	○
Microbiological	◒	○
Litter	●	○
BOD	◒	○
TDS	○	○

Notes:

- Nitrate and nitrite levels may actually increase due to nitrification.
- No performance data encountered in field demonstrations or in literature.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- Requirements: Mechanical skimmer or bladder will require inspection and periodic replacement.
- Nuisance Control: None beyond normal detention basin.
- Traffic Control: None identified.
- Staffing/Equipment: For routine maintenance, requires staff and equipment to inspect and maintain outlet.

Project Development:

- Right-of-Way Requirements: Equivalent to detention basin.
- Siting Constraints: None identified. Equivalent to detention basin.
- Retrofit Potential: Retrofit of EDBs at park-and-ride lots impact the operation of the facility during construction.
- Construction: Equivalent to detention basin.

Advantages:

- Savings from less frequent filter cleanings since cleaning a sedimentation basin is less difficult and expensive than cleaning a filter basin.
- Potentially increased removal of suspended solids.

Constraints:

- Unless the skimmer can drain all the water from the detention pond, a secondary outlet should be provided at the bottom of the basin to avoid water stagnation and the potential for mosquito propagation.
- Maintenance costs for sedimentation basins will be increased slightly since more sediments will accumulate in the sedimentation basin.
- May require draining the basin if the outlet fails.

Sources:

- http://www.epa.gov/ednnrmrl/projects/control/high.htm. April 2000.

Literature Sources of Performance Demonstrations:

- Harper, H. H., et al. "Performance Evaluation of Dry Detention Stormwater Management Systems." Sixth Biennial Stormwater Research Watershed Management Conference. September 1999.
- Keblin, Michael, et al. Effectiveness of Permanent Highway Runoff Controls: Sedimentation/Filtration Systems. October 1997.
- Meinholtz, T. L., et al. Screening/Floatation Treatment of Combined Sewer Outflows, Volume II: Full-Scale Operation Racine, Wisconsin. EPA-600/2-79-106a. Aug 1979.
- Pitt, R., et al. Stormwater Treatment at Critical Areas, Vol. 1: The Multi-Chambered Treatment Train. Cincinnati: US EPA. 1997.
- Robert Bein, William Frost and Associates, Scoping Study, Retrofit Pilot Program, Caltrans District 11. February 1998.
- Roy, John R. Corporate information packet. AquaLogic Stormwater Abatement Filter System. SWAF Inc. April 2000.
- United States Department of Transportation, Federal Highway Administration, Office of Environmental Planning: Evaluation and Management of Highway Runoff Water Quality, Washington, DC. June 1996.

Drain Inlet Insert – StreamGuard™

Description:

StreamGuard™ is placed in the inlet to a storm drain where storm water flows through the insert, and the geotextile fabric absorbs oil and retains sediment and gross pollutants. The body of the unit fills with storm water and sediment, and gross pollutants are collected in the bottom of the insert. Floating oil and grease are absorbed by the filter pack contained in a poly-net bag fixed within the unit.

Constituent Removal:

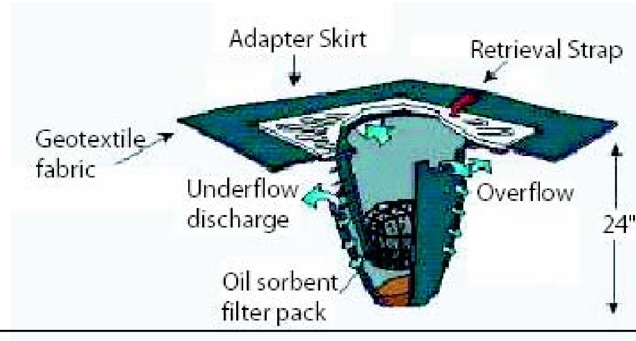
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	●
Nutrients	○	○
Pesticides	○	○
Total Metals	○	●
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- Three StreamGuard™ DIIs were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.

Caltrans SWMP Category:

Category III



Key Design Parameters:

StreamGuard™ should be installed into the inlet of the storm drain according to the manufacturer's recommendations. A tight seal is necessary between the frame of the drain inlet and the insert. The insert should have a high-flow bypass to prevent resuspension and washout.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		●

Information from Caltrans Cost Summary report CTSW-RT-01-003. An average of 17 field hours were spent operating and maintaining each StreamGuard™ in the 1999/2000 season.

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Sediment should be removed when accumulation is more than 6 inches. StreamGuard™ should be inspected for trash and debris that could interfere with the normal functioning of the inlets. The StreamGuard™ adsorbent should be replaced when significant oil and grease are present on the absorbent polymer. The media should be replaced annually.
- *Nuisance Control*: None
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Minimal space requirements for drain inlet insert.
- *Siting Constraints*: Drain Inlet Inserts should be installed where they can be easily accessible for maintenance.
- *Design Complexity*: Proprietary device.
- *Retrofit Potential*: DIIs located in maintenance stations will impact facilities, normal operations and may cause a loss of the available space normally used for parking vehicles or storing equipment and materials.
- *Construction*: The DIIs are designed to be part of the existing or new drainage system. Installation must include ensuring a tight fit between the device and the drain inlet lip.

Advantages:

- StreamGuard™ DIIs are relatively inexpensive to install, and are easily retrofitted to existing drain inlets.

Constraints:

- Constituent removal is relatively small. No treatment is provided for nutrient removal.

Sources:

- Foss Environmental
  PO Box 80327
  Seattle, Washington 98108 USA
  Tel (800) 909-3677 fax (888) 234-3677
  e-mail fossenv@fossenv.com
- StreamGuard™ is a proprietary device. Information provided by manufacturer can be found on their website at http://www.fossenv.com/

Literature Sources of Performance Demonstrations:

- None identified.

BMP Fact Sheet

Drain Inlet Insert – FossilFilter™

Description:

FossilFilter™ inserts are proprietary devices that contain filter media (Amorphous Alumina Silicate) just under the grates of the storm water system's catch basins. The water runoff flows into the inlet, through the filter where the target contaminants are removed, and then into the drainage system. It can be implemented anywhere free oil and grease (the primary target constituent) is considered a problem.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids	○	●
Nutrients	○	○
Pesticides	○	○
Total Metals	○	●
Dissolved Metals	○	○
Microbiological	○	○
Litter	●	●
BOD	○	○
TDS	○	○

Notes:

- Three FossilFilter™ DIIs were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.

Caltrans SWMP Category:

Category III

Key Design Parameters:

FossilFilter™ should be installed into the inlet of the storm drain according to the manufacturer's recommendations. A tight seal is necessary between the frame of the drain inlet and the insert. The insert should have a high-flow bypass to prevent resuspension and washout. The media should not be able to escape the unit. Even sheet flow to all sites of the inlet is optimal. Concentrated flow (as in a swale) creates a jet entering the inlet which can result in by-pass. The design loading rate is 12 gpm per foot of filter.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		●

Information from Caltrans Cost Summary report CTSW-RT-01-003. An average of 29 field hours were spent operating and maintaining each FossilFilter™ DII in the 1999/2000 season.

● High	◒ Medium	○ Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: FossilFilter™ should be inspected for trash and debris that could interfere with the normal functioning of the inlets, or debris that tends to accumulate on top of the trays, deflecting runoff water. The FossilFilter™ adsorbent should be replaced when significant oil and grease are present on the absorbent granules. The media should be replaced annually.
- Nuisance Control: None
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff to remove debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are very small.
- *Siting Constraints*: Drain Inlet Inserts should accessible as needed for maintenance.
- *Design Complexity*: Proprietary device.
- *Retrofit Potential*: Easily retrofitted to existing drain inlets.
- *Construction*: The DIIs are designed to be part of a new or existing drainage system. The edge where the device tray meets the inlet wall must be sealed to prevent runoff from by-passing the tray. DIIs located in maintenance stations will impact facilities' normal operations and may cause a loss of the available space normally used for parking vehicles or storing equipment and materials.

Advantages:

- FossilFilter™ are relatively inexpensive to install.
- Easily retrofitted to existing drain inlets.

Constraints:

- No treatment is provided for nutrient removal.
- Maintenance is dispersed rather than centralized at the storm drain outlet.
- They are not suitable for locations such as freeway shoulders where maintenance access is compromised.

Sources:

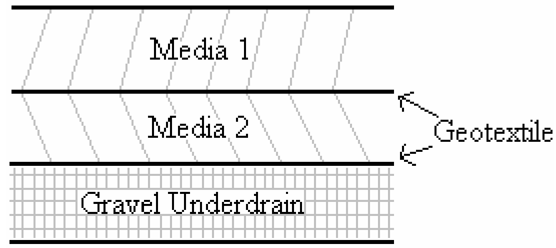
- KriStar Enterprises, Inc.
  P.O. Box 7352
  Santa Rosa, CA 95407-0352
  (800) 579-8819 FAX: (707) 524-8186
- FossilFilter™ is a proprietary device. Information provided by manufacturer can be found on their website at http://www.kristar.com/

Literature Sources of Performance Demonstrations:

- None identified.

Description:

The Dual Media Austin Filter is similar to an Austin Sand Filter. In the filter, the water passes through two media layers, a geotextile layer, and 6" of gravel. Particulate removal is achieved primarily by physical filtration of pollutants through the filtration media and settling of solids in the sedimentation basin. Dissolved pollutants are absorbed to the media. The second media typically has properties conducive to absorption. The arrangement tested by Caltrans consists of 0.4m (12") of Activated Alumina overlain by 0.2m (0.6") of sand. The sand on top will clog first. Replacement of clogged sand will be less expensive than if the entire filter where activated alumina.



see Austin Sand Filter fact sheet (C-2) for overall schematic.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	◒	◒
Pesticides	○	◒
Total Metals	◒	●
Dissolved Metals	○	●
Microbiological	●	●
Litter	●	●
BOD	○	●
TDS	○	●

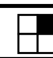
Notes:

- Data obtained from Caltrans Retrofit Pilot Program for five Austin sand filters and based on the small-scale Tahoe pilot studies.

Key Design Parameters:

1. Design volume for the sedimentation basin should be increased to account for reduction in storage volume due to deposition of solids.
2. Orifice plate on the outlet riser should be sized so that the sedimentation basin drains from a full basin condition in 24 hours.
3. The underdrain piping should consist of a main collector pipe and two or more lateral branch pipes with a minimum slope of 1%.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		●

Five Austin sand filters were constructed for retrofit and monitored. An average of 45 field hours/year was spent on O&M for each sand filter. Caltrans Cost Summary report CTSW-RT-01-003

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

Category III

Issues and Concerns:

Maintenance:

- *Requirements*: A maintenance ramp should be incorporated to allow equipment into the sedimentation basin and filter basin for routine cleaning sediment and debris.
- *Nuisance Control:* The spreader ditch in the filtration chamber holds water and can provide breeding habitat for mosquitoes. The spreader ditch may be omitted from the traditional design if another energy dissipation method is provided in front of the riser outlet to the filter bed.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for sedimentation basin and sand filter.
- *Siting Constraints*: Should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. Excessive amounts of sediment will cause premature clogging of the filter.
- *Design Complexity*: Sand filters should be sited where enough vertical clearance (head) is provided, about 1.5 meters. Detailed geotechnical investigation prior to construction is recommended.
- *Retrofit Potential*: Retrofit of sand filters at maintenance stations and park-and-ride lots impacts the operation of the facility during construction.
- *Construction:* Sand specified should be a standard locally available well-washed sand mix that generally meets the design requirements for permeability. Excavation problems may be magnified due to the large, deep design of the sedimentation basin and sand filter, the need to intercept existing storm drains, and the desire to minimize footprint area. Field conditions such as structurally unsuitable soils, buried manmade objects and existing utility lines may be encountered.

Advantages:

- The Austin filters have good constituent removal for suspended solids, total metals, and bacteria. They can provide consistent pollutant removal when properly maintained.
- They can treat runoff from drainage areas up to 20 hectares.
- They can reduce the potential for groundwater contamination if they are designed with an impermeable basin liner.
- They can be added to retrofit highly developed existing sites.

Constraints:

- Sand filters can be relatively expensive to construct and maintain.
- Limited pollutant removal for nutrients.
- If sufficient head is not available, the use of pumps may be required, which result in higher costs and more frequent maintenance.

Sources:

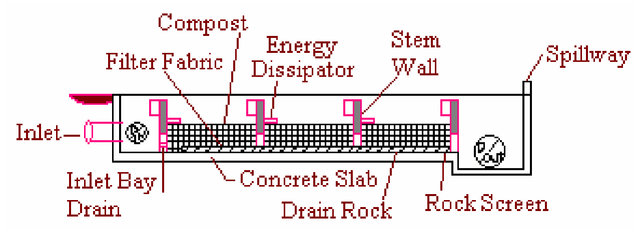
- M. Barrett, University of Texas at Austin
- http://www.epa.gov/owm/mtb/sandfltr.pdf
- http://enviro.nfesc.navy.mil/p2library/cgi-bin/p2h_datasheet.cfm?itemID=230
- http://webcentral.bts.gov/ntl/DOCS/RUNOFF.html

Literature Sources of Performance Demonstrations:

- The US Department of Transportation "Evaluation and Management of Highway Runoff Water Quality" Young et al. 1996 – contains info. on siting, design, and performance.
- Glick, Roger Chang, George C., and Barrett, Michael E., Monitoring and evaluation of stormwater quality control basins, in Watershed Management: Moving from Theory to Implementation, Denver, CO, May 3-6, 1998, pp. 369-376.

Description:

This filter is conceptually similar to the Austin Sand Filter (see page C-3, Appendix C), but uses a composted leaf filter media instead. Stormwater Management, Inc. is no longer manufacturing systems with this media. The filter is open to the atmosphere and requires a sedimentation basin upstream. The media is typically housed in a large below-grade vault. In some designs the vault is sectioned off by removable weirs, and under high flow conditions the storm water will overflow the first filter section to be treated in the subsequent ones. The filter media is reported to remove sediment, oil, particulate and dissolved metals, and a variety of organic contaminants. The assumption is that these systems will have enhanced removal for many pollutant compounds due to the increased cation exchange capacity of organic matter over sand. This technology is designed for use at the storm water pipe outlet. Alternative configurations, such as cylindrical filter modules, have been used in attempts to save space and reduce filter clogging.



Key Design Elements:

1. Proprietary design.

Ancillary Facilities

Sedimentation facilities required upstream of filter.

Equivalent Uniform Annual Costs:

	Cost Efficiency	*Level-of-Confidence*
EUAC		●

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	●
Nutrients	○	●
Pesticides	○	●
Total Metals	○	●
Dissolved Metals	○	●
Microbiological	○	●
Litter	●	◒
BOD	○	◒
TDS	○	●

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Caltrans SWMP Category:

- Category III

Issues and Concerns:

Maintenance:

- *Requirements*: Sediment accumulation in filters and vegetation growth may occur. Nutrient concentrations (especially nitrates and phosphate) have been shown to increase. Media clogging issues may increase maintenance.
- *Nuisance Control:* Standing water may provide a breeding place for mosquitoes and other vectors.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.

Project Development:

- *Right-of-Way Requirements:* Unknown.
- *Siting Constraints*: Safety barrier surrounding open basin. Open basins may not be suitable close to freeways.
- *Retrofit Potential*: Caltrans ROW space is typically limited particularly in highly urbanized areas.
- *Construction:* Traffic control required for retrofits due to close proximity to roadway.

Advantages:

- Sedimentation shown to occur. May reduce concentrations of many metals, turbidity, suspended solids, BOD, and ammonia.

Constraints:

- Open basins may not be suitable close to freeways.
- Nutrient leaching.

Sources:

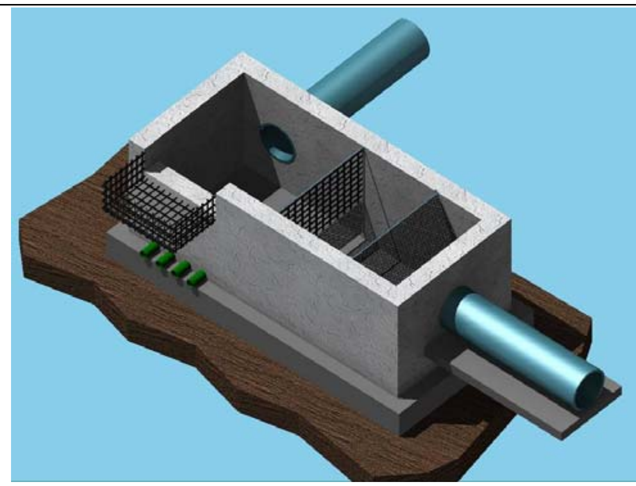
- Jim Lenhardt, Stormwater Management Inc.
- www.stormwatermgt.com

Literature Sources of Performance Demonstrations:

- Compost Storm Water Filter System Monitoring Report , State Route 73 CSTW-RT-03-036 http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/index.htm

Description:

The Baffle Box Gross Solids Removal Device (GSRD) is a non-proprietary device whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. The Baffle Box applies a two-chamber concept: the first chamber utilizes an underflow wire to trap floatable gross solids; and the second chamber utilizes a bar rack to screen out any material that passes through from the first chamber.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate the treatment effectiveness of the Baffle Box on other water quality constituents.

Key Design Parameters:

1. Hydraulic Head
2. Annual Estimated Gross Solids Loading Rate

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		○

Caltrans SWMP Category:

Category III

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements:* Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Traffic Safety*: Traffic control may be required during maintenance.
- *Staffing/Equipment:* Routine maintenance requires staff and equipment to clear the bar rack if it becomes clogged and remove accumulated sediment.

Project Development:

- *Right-of-Way Requirements*: Requires access for maintenance**.**
- *Siting Constraints*: Must provide sufficient hydraulic head to operate by gravity.
- *Design Complexity*: Baffle boxes should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).
- *Retrofit Potential*: Can be installed in existing right-of-way, but access is required.
- *Construction***:** Traffic control may be required for retrofits due to close proximity to roadway.

Advantages:

- Baffle box is a "small footprint device" that can be installed in existing right of way.
- Based on pilot studies, when regular maintenance is supplied, the device removes nearly all the gross solids from storm water runoff.

Constraints:

- Based on pilot studies, regular maintenance is required to keep the device functioning properly.

Sources:

- Suntree Technologies Inc.
- http://bafflebox.com
- California Department of Transportation

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase I Gross Solids Removal Devices Pilot Study: 2000-2002, Final Report.

Description:

The Inclined Screen (IS) Gross Solids Removal Devices (GSRDs) are non-proprietary devices whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. Currently, there are four configurations of IS GSRDs:

Configuration #1. This IS GSRD utilizes a 3 mm spaced parabolic wedge-wire screen. The device is configured with an influent trough to allow some solids to settle. See picture to the right.

Configuration #2. This IS GSRD utilizes 5 mm spaced parabolic bars. The device is configured with an influent trough to allow some solids to settle. Configuration #2 is not pictured.

Configuration #3. This IS GSRD utilizes the same screen as Configuration #1. However, Configuration #3 has been designed to be cleaned by a front-end loader instead of a Vactor Truck. Configuration #3 is not pictured.

Configuration #4. This IS GSRD is similar to the Configuration #1 except that the screen is not parabolic and the influent trough has been removed from the design. Configuration #4 is not pictured.

Constituent Removal:

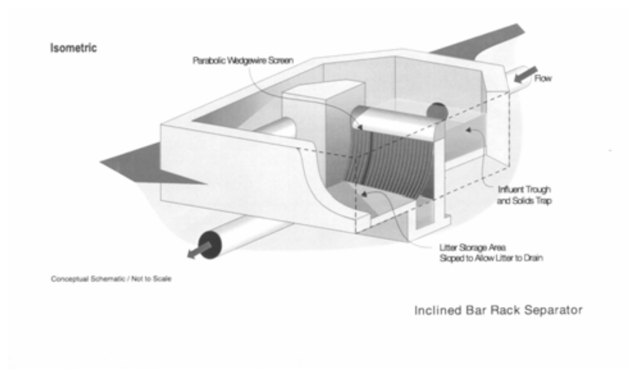
Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness of the IS GSRDs on other water quality constituents.

Caltrans SWMP Category:

Category III



Key Design Parameters:

1. Hydraulic Head
2. Annual Estimated Gross Solids Loading Rate

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		○

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Traffic Control*: Traffic control may be required during maintenance.
- *Staffing/Equipment* Routine maintenance requires staff and equipment to clear the screen module if it becomes clogged and remove accumulated sediment.

Project Development:

- *Right of Way Requirements*: Requires access for maintenance.
- *Siting Constraints*: Must provide sufficient hydraulic head to operate by gravity.
- *Design Complexity*: IS GSRDs should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).
- *Retrofit Potential*: Can be installed in existing right-of-way, but access is required.
- *Construction*: Traffic control may be required for retrofits due to close proximity to roadway.

Advantages:

- The IS GSRDs are a "small footprint device" that can be installed in existing right of way.
- Based on pilot studies, the devices remove nearly all the gross solids from storm water runoff with minimal maintenance requirements.

Constraints:

- Hydraulic head requirement.

Sources:

- California Department of Transportation

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase I Gross Solids Removal Devices Pilot Study: 2000-2002, Final Report.
- California Department of Transportation, Phase II Gross Solids Removal Devices Pilot Study: 2001-2003, Final Report.
- California Department of Transportation, Phase III Gross Solids Removal Devices Pilot Study: 2002-2003, Interim Report.

Description:

The Linear Radial (LR) Gross Removal Devices (GSRDs) are non-proprietary devices whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. Currently, there are three configurations of LRDs:

Configuration #1. This LR GSRD utilizes a modular well casing with 5 mm x 64 mm louvers to serve as the screen. The LR GSRD is placed on a 2-percent slope. See picture to the right.

Configuration #2. This LR GSRD utilizes a modular 5 mm x 5 mm rigid mesh screen housing. Inside the rigid mesh screen are nylon mesh bags (5 mm mesh) that capture gross solids. Configuration #2 is not pictured.

Configuration #3. This LR GSRD is identical Configuration #1 except that it has been placed on an approximately 40-percent slope. Configuration #3 is not pictured.

Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness of the LR GSRDs on other water quality constituents.

Caltrans SWMP Category:

Category III

Key Design Parameters:

1. Annual Estimated Gross Solids Loading Rate

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		○

●	◓	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Traffic Control*: Traffic control may be required during maintenance.
- *Staffing/Equipment:* Routine maintenance requires staff and equipment to clear the screen module if it becomes clogged and remove accumulated sediment.

Project Development:

- *Right-of-Way Requirements*: Requires access for maintenance.
- *Siting Constraints*: Must provide sufficient area to accommodate the length of LR GSRD required.
- *Design Complexity*: LR GSRDs should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).
- *Retrofit Potential*: Can be installed in existing right-of-way, but access is required.
- *Construction:* Traffic control may be required for retrofits due to close proximity to roadway.

Advantages:

- The LR GSRDs are a “small footprint device” that can be installed in existing right of way.
- Based on pilot studies, the devices remove nearly all the gross solids from storm water runoff with minimal maintenance requirements.

Constraints:

- Surface area requirement.

Sources:

- Roscoe Moss Company
- http://www.roscoemoss.com/gsrd.html
- email info@roscoemoss.com
- California Department of Transportation

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase I Gross Solids Removal Devices Pilot Study: 2000-2002, Final Report.

Description:

Standard Caltrans inlet and grate is replaced with a curb inlet and flap gate.

Constituent Removal:

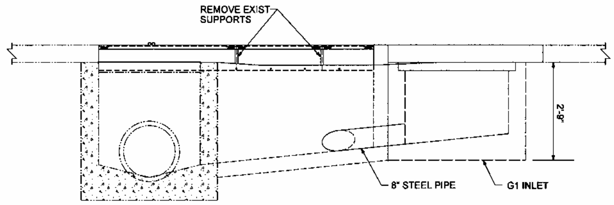
Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	○
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	◒	◒
BOD	○	○
TDS	○	○

Notes:

- No performance data encountered in literature
- Field evaluation of prototype is currently being conducted on Highway 60 in the Los Angeles area.

Caltrans SWMP Category:

Category III



Key Design Parameters:

Curbed roadway is required.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▖	◒

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Flab gate requires periodic clean-out.
- Nuisance Control: None identified.
- *Traffic Safety*: None identified.
- *Staffing/Equipment:* Staff and equipment required to maintain flap gate and clean-out system.

Project Development:

- Right-of-Way Requirements: Small-footprint.
- *Siting Constraints*: Curbed roadway is required.
- *Retrofit Potential*: May be implemented on curbed roadways.
- *Construction:* None identified.

Advantages:

- Keeps dry-weather deposition out of storm water conveyance system and allows most gross pollutants to be collected by the street sweeper. Most effective in arid or semi-arid climates.

Constraints:

- Larger items can enter the LID than the standard inlet grate during storms.
- Flap gate may require maintenance and system clean out.

Sources:

- URS, 1615 Murray Canyon Road, Suite 1000, San Diego, CA 92108 619•294•9400
  - David Marx (davis_marx@urscorp.com)
  - Kim Walter (kim_walter@urscorp.com)

Literature Sources of Performance Demonstrations:

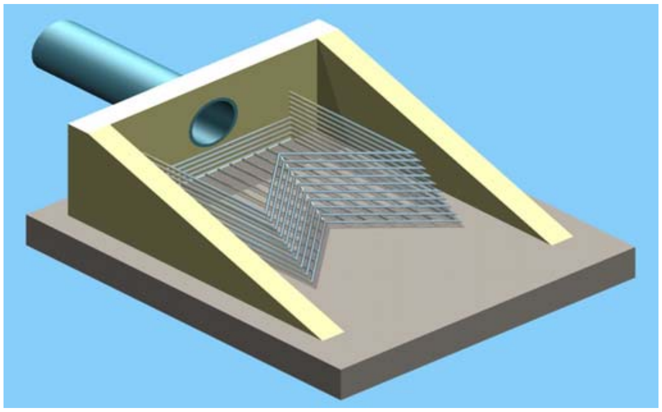
- None identified.

Description:

The V-Screens (VS) Gross Solids Removal Devices (GSRDs) are non-proprietary devices whose primary function is to remove gross solids (litter and vegetative material) from storm water runoff. Currently, there are two configurations of VS GSRDs:

Configuration #1. This VS GSRD utilizes a forward sloping V-shaped 5 mm wedge-wire screen. The screen is sloped forward so that the top of the screen is downstream from the bottom of the screen. Configuration #1 is not pictured.

Configuration #2. This VS GSRD utilizes a reverse sloping V-shaped 5 mm wedge-wire screen. The screen is sloped backward (or reverse) so that the bottom of the screen is downstream from the top of the screen. See picture to the right.



Constituent Removal:

Constituent Group	***Removal Efficiency***	***Level-of-Confidence***
Total Suspended Solids		
Nutrients		
Pesticides		
Total Metals		
Dissolved Metals		
Microbiological		
Litter	●	●
BOD		
TDS		

Notes:

- Litter and vegetative material are the target constituents for the device.
- No long-term water quality monitoring studies have been conducted to evaluate treatment effectiveness of the VS GSRDs on other water quality constituents.

Caltrans SWMP Category:

Category III

Key Design Parameters:

1. Hydraulic Head
2. Annual Estimated Gross Solids Loading Rate

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC	◲	○

●	◓	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Periodic inspections required to ensure that the device is functional. Routine maintenance may include sediment/debris removal.
- *Nuisance Control:* Design should eliminate standing water that may provide breeding habitat for vectors.
- *Traffic Control*: Traffic control may be required during maintenance.
- *Staffing/Equipment:* Routine maintenance requires staff and equipment to clear the screen module if it becomes clogged and remove accumulated sediment.

Project Development:

- *Right-of-Way Requirements*: Requires access for maintenance.
- *Siting Constraints*: Must provide sufficient hydraulic head to operate by gravity.
- *Design Complexity*: VS GSRDs should be sized to hold gross solids to be deposited during a 1-year period and pass the design flow (e.g., 25-year flow).
- *Retrofit Potential*: Can be installed in existing right-of-way, but access is required.
- *Construction:* Traffic control may be required for retrofits due to close proximity to roadway.

Advantages:

- The IS GSRDs are a “small footprint device” that can be installed in existing right of way.
- Based on pilot studies, the devices remove nearly all the gross solids from storm water runoff with minimal maintenance requirements.

Constraints:

- Hydraulic head requirement.

Sources:

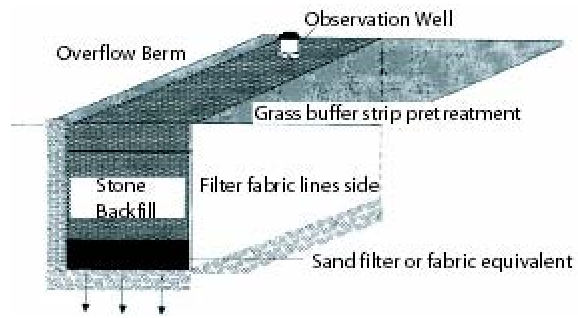
- California Department of Transportation

Literature Sources of Performance Demonstrations:

- California Department of Transportation, Phase III Gross Solids Removal Devices Pilot Study: 2002-2003, Interim Report.

Description:

An infiltration trench is typically a long and narrow excavation that is lined with filter fabric and backfilled with stone aggregate or gravel to form an underground basin. Runoff is diverted to the trench and infiltrates into the soil. Pollutants are filtered out of the runoff as it infiltrates the surrounding soils. Infiltration trenches are best sited in areas where soils meet the minimum infiltration rate. Regulators may caution against installation in highly industrial areas or areas where highly soluble constituents may be discharged to the trench.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	●	●
Pesticides	●	●
Total Metals	●	●
Dissolved Metals	●	●
Microbiological	●	●
Litter	●	●
BOD	●	●
TDS	●	●

Notes:

- Constituent removal is considered 100% for the design water quality volume since the entire water quality volume is infiltrated and no water is discharged to surface waters. However, groundwater contamination can occur from soluble constituents that may not be retained in the soil matrix.
- Two infiltration trenches were sited, constructed, and monitored as part of the Caltrans BMP retrofit pilot program.

Caltrans SWMP Category:

Category III

Key Design Parameters:

An infiltration rate of at least 14 mm/hr is desired. This infiltration rate would be found in soils with low silt and clay content. The groundwater separation should be a minimum of 3.0 m. Trenches should be designed to drain within 72 hours to prevent potential vector problems. A large bottom surface area is desired because it allows an increased infiltration rate and reduces the amount of clogging. Use of a biofiltration strip as pretreatment to remove floatables and sediment from runoff before entering the infiltration trench is recommended. The trench volume should be determined by assuming the Water Quality Volume (WQV) will fill the void space based on the computed porosity of the rock matrix. Backfill material for the trench should be 1-in to 3-in rock or equivalent locally available material.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	***Level-of-Confidence***
EUAC		●

Costs include the construction of a pretreatment biofiltration strip. Cost information is from Caltrans Cost Summary report CTSW-RT-01-003. An average of 13 field hours were spent operating and maintaining each infiltration trench in the 1999/2000 season.

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- Requirements: Maintenance requirements include regular inspections to confirm trench is draining within 72 hours. Trash and debris should be removed from the site on a regular basis. Sediment accumulation should be inspected and, if visible on top of the trench, the top layer of trench, silt, filter fabric, and stone should be removed. The stone should be washed and fabric and stone reinstalled in trench.
- Nuisance Control: Inspect for standing water at the end of the wet season. No additional nuisance control necessary if drained properly.
- Traffic Control: If located along a shoulder or median, maintenance activities will require traffic control.
- Staffing/Equipment*:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- Right-of-Way Requirements: Space requirements are relatively high for infiltration trenches.
- Siting Constraints: Infiltration trenches should not be sited within 30 meters of building or bridge foundations. Infiltration trenches sited within 30 meters would require detailed site structural and geotechnical investigation. Infiltration trenches are suitable for drainage areas up to 4 hectares. Trenches work best at sites with a upgradient drainage area slope of less then 5%. Trenches should be sited where infiltration rates are at least 14mm/hr and there is at least 3.0 meters separation between trench invert and the groundwater. Trenches are not recommended in industrial land use areas or in locations were soluble constituents may impact ground water quality.
- Retrofit Potential: Where space and sufficient water table depth permits.
- Construction***:*** During excavation for trench construction, light equipment should be used to avoid compaction of the soil. Field conditions, such as structurally unsuitable soils, and existing utilities lines may be encountered, and detailed geotechnical investigation prior to construction is recommended. Retrofit of infiltration trenches at maintenance stations impacts the operation of the facility during construction. A geotechnical engineer must be present during the excavation to ensure that there are no anomalies encountered in the soil lithology that would inhibit infiltration. During design, sufficient borings are required to determine the presence of unsuitable materials. Stabilize the entire area draining to the facility before construction begins. If impossible, place a diversion berm around the perimeter of the infiltration site to prevent sediment entrance during construction. Stabilize the entire contributing drainage area before allowing any runoff to enter once construction is complete.

Advantages:

- Due to the infiltration of the entire water quality volume, the constituent removal is considered 100%. Infiltration trenches take up little land area and are not highly visible.

Constraints:

- Infiltration trenches must have soils with a high enough permeability rate and suitable groundwater separation.
- If not properly maintained they will prematurely clog.
- Pretreatment is required to reduce the amount of influent sediment.
- Major maintenance (removal and replacement of the rock matrix) is relatively costly.

Sources:

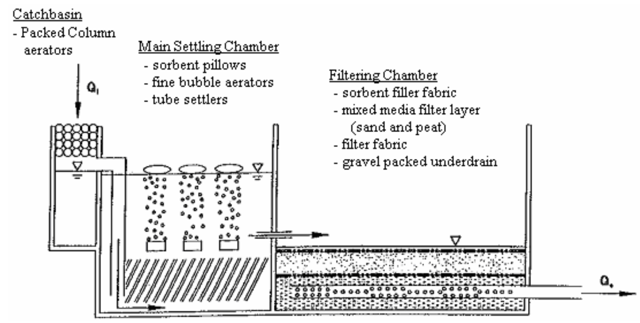
- http://www.epa.gov/owm/mtb/infltrenc.pdf
- http://h2osparc.wq.ncsu.edu/river/industrial/industri.html#cm
- http://www.stormwater-resources.com/Library/116BBMP%20Guide.PDF

Literature Sources of Performance Demonstrations:

- Schueler, T.R., 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.
- Young, G.K., et al. 1996, Evaluation and Management of Highway Runoff Water Quality, Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning.

Description:

Multi-Chambered Treatment Trains (MCTTs) use three treatment mechanisms. The first chamber is a catch basin used to remove large, grit-sized material. The second chamber is a settling chamber that removes settleable solids with plate separators and oil and grease with sorbent pads. The third chamber is a sand/peat filter. These devices were originally designed to reduce toxicity in the runoff from critical storm water source areas and can be implemented where toxicity in runoff is an identified problem.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	○	●
Pesticides	○	○
Total Metals	◒	●
Dissolved Metals	○	●
Microbiological	●	●
Litter	●	●
BOD	○	○
TDS	○	○

Notes:

- Nitrate concentrations increase by 62%.
- High dissolved Zn removal.
- Two MCTTs were sited, constructed, and monitored as part of the Caltrans' BMP retrofit pilot program. An analysis of the influent and effluent water quality data for the filters indicated that there was no significant difference among the sites for the constituents monitored; therefore, the data for all sites were treated as if they came from a single site.

Key Design Parameters:

MCTTs are designed as 3-stage devices. The first stage consists of a catch basin with a sump and packed column aerators. The volume of the catch basin is determined based on the desired maintenance frequency of the sump with the variables of discharge and influent TSS.

The second stage is the main settling chamber. The design volume is highly dependent on local rainfall characteristics. A computer model is used to analyze rainfall data from a given area with the chamber design variables of settling depth and detention time (typically 72 hrs). Gravity draining or pumps can be used to transfer runoff from the main settling chamber to the filtration chamber.

The filtration chamber consists of 450-mm filter media layer consisting of a 50/50 mixture of sand and peat moss. The layer is separated from a gravel-packed underdrain by a layer of filter fabric. The filter area is determined from the recommended solids loading rate of the peat/sand mixture of 5000 g TSS/m2/year. Gravity draining or pumps can be used to return the filtered runoff to the drainage system.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	●

Information obtained from Caltrans Cost Summary report CTSW-RT-01-003 An average of 120 field hours per year were spent on operation and maintenance of each MCTT during the Caltrans BMP retrofit pilot program.

Caltrans SWMP Category:

Category III

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: MCTTs requiring the use of pumps require additional maintenance for the pumps and associated electrical circuits. Minor structural repairs of cracks that form in the structure may be required. Major maintenance activities are hampered by the lack of adequate access to the settling and filter chambers.
- *Nuisance Control:* The MCTTs maintain a permanent pool of water below the tops of the tube settlers; this pool of water provides a breeding site for mosquitoes.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Space requirements are relatively high for MCTTs.
- *Siting Constraints*: MCTTs should be sited where there is a small, impervious contributing watershed. They should not be sited where runoff from bare soil or construction activities will be allowed to enter the filter. MCTTs should be sited where enough vertical clearance (head) is provided, about 2 meters.
- *Design Complexity*: The sand is a special gradation requiring additional time and expense.
- *Retrofit Potential*: The hydraulic head requirement reduces the potential number of sites that could be retrofitted without the use of pumps.
- *Construction:* Material availability for the filter, excavation for the device/unknown field conditions, and interface with existing activities at the site are the primary issues to be addressed in the construction of MCTTs. The tube settler system is a special-order item with a significant lead-time. Unsuitable soil and unmapped utilities may be encountered since significant excavation is required. Construction within park-and-ride facilities have limited work area, and coordination with normal facility operations is required.

Advantages:

- The MCTTs have constituent removal for suspended solids, metals, and bacteria similar to that for an Austin Sand Filter. They can provide consistent pollutant removal when properly maintained. The target area for use of MCTTs are vehicle service facilities, parking areas, paved storage areas, and fueling stations with drainage areas up to 1 hectare.

Constraints:

- MCTTs are significantly more expensive to construct than gravity-drained Austin Sand Filters, which provide comparable performance.
- A permanent pool of water is maintained in the MCTT, which increases vector concerns.
- The presence of tube settlers in the sedimentation basin impedes maintenance activities.

Sources:

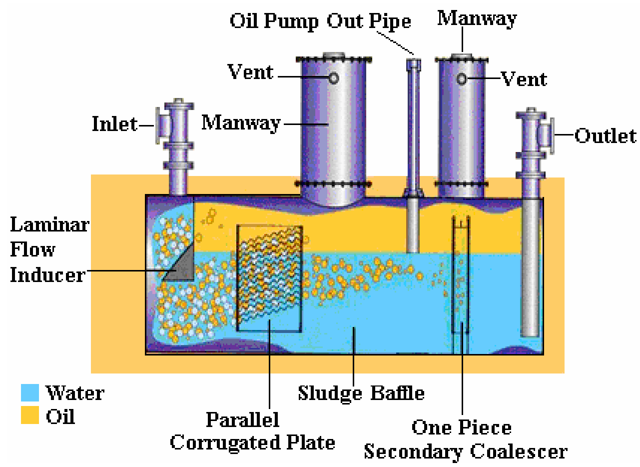
- Design guidelines for MCTTs and performance evaluation are presented in the report entitled, Stormwater Treatment at Critical Areas, Volume 1: The Multi-Chambered Treatment Train (MCTT), by Robert Pitt, et. al., dated October 1997, EPA/600/X-97/XXX.

Literature Sources of Performance Demonstrations:

- Design guidelines for MCTTs and performance evaluation are presented in the report entitled, Stormwater Treatment at Critical Areas, Volume 1: The Multi-Chambered Treatment Train (MCTT), by Robert Pitt, et. al., dated October 1997, EPA/600/X-97/XXX.

Description:

Oil/Water Separators are designed to remove free oil and grease from storm water runoff. Oil droplets collide and coalesce to become larger globules that are captured in the separator. Oil/Water separators are typically manufactured units. They consist of a baffled vault containing several inclined corrugated plates stacked and bundled together. The plates are equally spaced and reduce the vertical distance oil droplet must rise to separate from the storm water. With current technology and design, coalescing plate separator type oil/water separators are capable of reducing effluent concentrations of free oil and grease to 10 - 15 mg/L, and should be used where concentrations of oil and grease are high.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	○	●
Nutrients	○	○
Pesticides	○	○
Total Metals	○	○
Dissolved Metals	○	○
Microbiological	○	○
Litter	○	○
BOD	○	○
TDS	○	○

Notes:

- One oil/water separator was sited as part of the Caltrans BMP Retrofit Pilot Program. Concentration reductions presented are those found in the study.

Caltrans SWMP Category:

Category III

Key Design Parameters:

To design the coalescing plate separator the "effective separation area" required for the plate media needs to be determined given a design flow. The specific vault sizing will then depend on the manufacturer's plate media design. The specific design, analysis, configuration, and specifications for coalescing plates are empirically based and variable. Refer to manufacturer recommendations. An oil/water separator typically consists of three compartments divided by baffles: a forebay, an oil separation cell, and an afterbay. Sediments are trapped and collected in the forebay. The oil separation cell is used to capture and hold oil. The afterbay allows a relatively oil-free exit cell before the outlet.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		●

Information from Caltrans Cost Summary report CTSW-RT-01-003. Twenty-seven field hours were spent operating and maintaining the oil/water separator in the 1999/2000 season.

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Oil/Water separators require regular inspection. The separator plates require cleaning when sufficient oil and grease have accumulated and their effectiveness is reduced. Inspection and cleaning should follow manufacturers recommendations. Accumulated sediment should be removed frequently to prevent resuspension. Sediment removal also removes the oil and grease since these pollutants bind to the sediment.
- *Nuisance Control*: None
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* For routine maintenance, requires staff and equipment to remove sediment and debris.

Project Development:

- *Right-of-Way Requirements*: Must have room for excavation equipment to operate.
- *Siting Constraints*: Oil/water separators should be sited where higher concentrations of free oil and grease are found in the storm water.
- *Design Complexity*: Separators should precede all other stormwater treatment. Appropriate removal covers must be provided that allows access for observation and maintenance. Any pump mechanism should be installed downstream of the separator to prevent oil emulsification.
- *Retrofit Potential*: Most sites investigated as part of the Caltrans BMP retrofit pilot program had initial concentrations of oil lower than those that could be treated by an oil/water separator device.
- *Construction***:** Oil/water separators constructed at maintenance stations impact the stations during construction. The facilities will lose some space and coordination with maintenance station supervisor is required. Underground utilities may also be present.

Advantages:

- Oil/water separators are installed underground so they are not an aesthetic problem. Where high concentrations of free oil are present they can provide significant reduction.

Constraints:

- Accumulated sediment must be removed or cleaned out frequently to prevent resuspension.
- The concentrations of free oil and grease typically found in storm water runoff are generally too low to benefit from treatment by this device.
- Significant excavation is required for construction.

Sources:

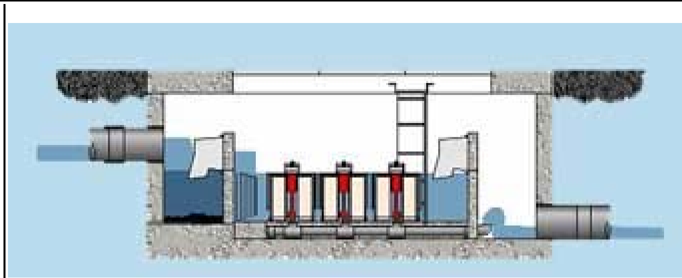
- Highland Tank
  One Highland Road
  Stoystown, PA 15563
  814-893-5701
  FAX 814-893-6126

Literature Sources of Performance Demonstrations:

- None identified.

Description:

StormFilter™ is a flow-through system consisting of a vault with canisters filled with filter media. The media traps particulate and adsorbs pollutants such as suspended solids, oil and grease, some metals, nutrients and organics. Various media can be specified (depending on the constituent of concern) including perlite, composted leaf media, zeolite, fabric inserts, GAC, and iron-infused media.



Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	◒	●
Nutrients	○	●
Pesticides	○	○
Total Metals	◒	●
Dissolved Metals	◒	●
Microbiological	○	●
Litter	●	○
BOD	○	○
TDS	◒	○

Notes:

- A StormFilter™ was sited as part of the Caltrans BMP retrofit pilot program. The canisters contained a mixture of perlite and zeolite.

Key Design Parameters:

StormFilter™ is sized to treat the peak flow from the design storm. The peak flow is determined based on the watershed area and design storm magnitude. StormFilter™ canisters are designed to treat 0.033 cfs each or 30 media canisters per c.f.s. of storm water runoff.

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC	▝	●

Cost information obtained from Caltrans Cost Summary report CTSW-RT-01-003. An average of 30 field hours per year was spent on operation and maintenance of the StormFilter™ during the Caltrans BMP retrofit pilot program.

Caltrans SWMP Category:

Category III

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- <u>*Requirements*</u>: Vaults should be free of trash and debris. Periodic maintenance is required to remove sediment that accumulates in the vaults.
- <u>*Nuisance Control*</u>*:* A permanent pool of water is held in the pretreatment vault that provides breeding habitat for mosquitoes.
- <u>*Traffic Control*</u>: If located along a shoulder or median, maintenance activities will require traffic control.
- <u>*Staffing/Equipment*</u>*:* The use of heavy equipment is needed to remove media canisters and to clean out pretreatment vault.

Project Development:

- <u>*Right of Way Requirements*</u>: The StormFilter™ requires access adjacent to the sediment and media vault.
- <u>*Siting Constraints*</u>: Runoff from bare soil or construction activities should not be allowed to enter the filter.
- <u>*Design Complexity*</u>: Sufficient hydraulic head is needed to operate the filter, about 0.7-m. StormFilter is a proprietary system.
- <u>*Retrofit Potential*</u>: It can be applied in confined urban areas and areas with limited space since it is an underground vault.
- <u>*Construction*</u>***:*** Stormwater Management, Inc. (SMI) provides media cartridge filters in pre-cast vaults as a package system. During the design and construction phase, it may be difficult to obtain the specific design details on the vaults and appurtenances required to prepare the construction drawings and specifications.
- Detailed geotechnical investigation is recommended for all sites.
- There are often easements to utility service providers, coordination with utility service providers is required due to excavation for vaults.
- The BMPs are designed to be part of the existing or new drainage system.

Advantages:

- StormFilter™ has moderate constituent removal for suspended solids, nutrients, and metals. It can be applied in confined urban areas and areas with limited space since it is an underground vault.

Constraints:

- StormFilter™ can be expensive to construct.
- A permanent pool of water is held in the pretreatment vault that provides breeding opportunities for mosquitoes.
- Major maintenance may be costly due to the large number of filter canisters required (72 canisters for a 1.5 acre drainage area).

Sources:

- Stormwater Management Inc.
  2035 NE Columbia Blvd.
  Portland, OR 97211
  800-548-4667
- EPA website includes information on design and performance of StormFilter™ http://www.epa.gov/region01/steward/ceit/tech_cos/sto.html
- StormFilter™ is a proprietary system, check the manufacturers website for information on the product. www.stormwatermgt.com.

Literature Sources of Performance Demonstrations:

- None identified.

Description:

A wet basin holds a permanent pool of water designed to detain and treat a runoff water quality volume. The basins support plant species, which may provide constituent removal by biological processes. In addition, the vegetation may help reduce erosion of the sides slopes and help trap sediments. Sedimentation processes also occur in the basin. The basins are usually deep enough to prevent resuspension of particles. Wet basins should be sited where a permanent pool of water can be maintained from a dry weather flow source.

Constituent Removal:

Constituent Group	*Removal Efficiency*	*Level-of-Confidence*
Total Suspended Solids	●	●
Nutrients	◒	●
Pesticides	○	○
Total Metals	●	●
Dissolved Metals	◒	●
Microbiological	●	●
Litter	●	○
BOD	◒	○
TDS	●	○

Notes:

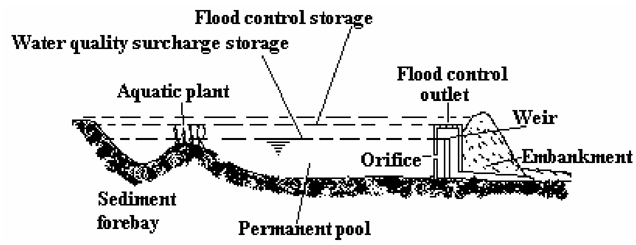
- Nitrate storm water concentrations increase by 132%, however dry weather flow reductions caused a net annual removal of total nitrogen.
- 94% removal efficiency for dissolved Pb.
- A wet basin was sited as part of the Caltrans BMP Retrofit Pilot Program. Constituent reduction found during this study is comparable to those reductions found in other studies.

Caltrans SWMP Category:

Category III

Key Design Parameters:

Wet basins should be sized to hold the permanent pool and the water quality volume required. In addition, a 10% increase should be provided for solid deposition storage. The water quality volume above the permanent pool should drain within 24-48 hours. The basin should have a minimum length to width ratio of 1:1 and a preferred ratio of 3:1. The maximum depth of 2.4 meters and average depth of 1-2 meters. The volume of the permanent pool should be one to three times the water quality volume. Basin side slopes should be 3:1 or flatter.
Wet basin should include a sediment forebay and a main pool. The sediment forebay should be sized to be 15-25% of the permanent pool volume and at least 1 meter deep, separated from the main pool by a earthen berm, gabion, or loose riprap wall. The berm should have a 1.5-meter top width and an elevation 1-foot lower than the design water surface. Vegetation should be planted around the perimeter of the basin. For ponds designed as offline facilities, a splitter structure should be used.



(modified from Urbonas And STAHRE, 1993)

Equivalent Uniform Annual Costs:

	Cost Effectiveness	*Level-of-Confidence*
EUAC		●

Cost information obtained from Caltrans Cost Summary report CTSW-RT-01-003. An average of 500 field hours per year was spent on operation and maintenance of the La Costa wet basin during the Caltrans BMP retrofit pilot program. This included 440 hours spent on harvesting of the vegetation and other vegetation management.

●	◒	○
High	Medium	Low

Rating Key for Constituent Removal and Level-of-Confidence

Benefit ↑ Cost ↓	Benefit ↑ Cost ↑
Benefit ↓ Cost ↓	Benefit ↓ Cost ↑

Rating Key for Cost Effectiveness

Issues and Concerns:

Maintenance:

- *Requirements*: Inspections should be conducted to ensure that the structure operates as intended. The embankment should be checked for subsidence, erosion, leakage, cracking, and tree growth. Debris and litter should be removed from the basin to prevent clogging of the outlet. Sediment accumulation in the basin will reduce the storage capacity and removal performance of the basin. Sediment should be removed when it accumulates to 10% of the basin volume. Wet basin plant material should be harvested on an annual basis.
- *Nuisance Control:* Wet basins provide a pool of water and dense vegetation that is ideal for mosquito breeding. The basins should be stocked with mosquito fish to control the population.
- *Traffic Control*: If located along a shoulder or median, maintenance activities will require traffic control.
- *Staffing/Equipment:* Requires staff and equipment for routine maintenance.

Project Development:

- *Right-of-Way Requirements*: Space requirements are high for wet basins.
- *Siting Constraints*: Wet basins are best sited for highways in residential or commercial areas with a combined drainage area greater than 8 ha. Significant off-site drainage with year round base flow is needed. A wet basin usually has an area of 1 to 3 percent of the contributing drainage area. Since the basin required a permanent pool of water, the soil should have a low infiltration rate or be lined with a clay of geotextile liner.
- *Design Complexity*: Wet basins should be sited where a permanent pool of water can be maintained from a dry weather flow source.
- *Retrofit Potential*: Best for highways in residential or commercial areas to accommodate space requirements.
- *Construction*: Excavated soil surface should be suitable to support plant life. If a pond liner is used, it must be carefully constructed to avoid punctures.

Advantages:

- Wet basins have good removal efficiencies providing storm water quality benefits.
- They can also have recreational and aesthetic benefits.

Constraints:

- Wet basins must be properly maintained to prevent stratification and anoxic conditions, which would allow resuspension of solids and release of nutrients and metals.
- A permanent pool of water must be maintained and therefore may have limitations on siting.
- There are potential problems associated with mosquitoes and the device may become a regulated wetland if not consistently maintained per an established schedule.
- They require more area than an extended detention basin.

Sources:

- http://www.epa.gov/owm/mtb/wetdtnpn.pdf
- http://h2osparc.wq.ncsu.edu/wetland/aqlife/urbstorm.html#cm

Literature Sources of Performance Demonstrations:

- Information on design and performance of wet basins can be found in the following references:

- King County, 1996, Surface Water Design Manual (Draft), King County Surface Water Management Division, Washington.
- Schueler, T.R., 1987, Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, DC.
- Urbonas, B.R., et al., 1992, Urban Storm Drainage Criteria Manual, Volume 3 – Best Management Practices, Stormwater Quality, Urban Drainage and Flood Control District, Denver, CO.